# **Exploding** Alarm Clock

Group #10

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# Table of Contents

# 1. Introduction

## 1.1. Executive Summary

The Exploding Alarm Clock is meant to be a unique take on an existing technology. The main design involves a simple alarm clock with enhancements to make it a new and distinct product that is marketable to a number of different audiences. The “exploding” feature of the design is handled by spring launching the speakers from the base, to give the user a reason to get out of bed. This feature also doubles as a way to have the speakers separate from the base while in casual listening mode. To give the user more of a variety when selecting alarms and during casual listening, a USB connection is provided to allow user music files to be played. This design is very scalable and as a result many features have been added to the design to increase the user options and uniqueness. The alarm clock base will also house an LCD screen for information display that will include time, alarm, and music selections. The overall design revolves around user friendliness and its many available special features to help its marketability.

There are a few objectives that needed to be kept in mind throughout the planning and designing of this project. One of the main objectives was to create a unique design that has a flexible set of features that will enhance its functionality. This has provided for other objectives such as making a marketable product that will draw consumers in with its feature set. It was also important to keep the project simple when it comes to user interfacing. This was vital to keeping consumers interested in the product which will help popularity resulting in increased sales. Another objective, which was stated as what the overall design revolves around is the user friendliness. If the user can not figure out how to use the alarm clock and all of its features, then the features mean nothing and the product has failed. The user friendliness of the final product needs to be high enough where the users of all ages have no problem interfacing with the alarm clock and its features. It is also important to provide a technically advanced product with a simple presentation.

In order to present the final design following all of the specific goals and objectives the technical aspect of the design needs to be carefully approached with a consideration to the user. Keeping in mind that the technical side of the project will need to compliment the user friendliness, a precise technical approach can be defined and followed. The programming of the microcontroller will be the key to providing the desired user interface. The program integrates all of the design modules together as well as providing a simple interface to the user. With all of these things under consideration, the final design does provide a technically complex design, while still providing a relatively simple and user friendly interface.

## 1.2 Motivation and Goals

The motivation for this project was to create a clock that is both fun and functional to the everyday user. The designers of this clock wanted to create a unique device to wake the user from slumber. Through the inventive method of projecting the speakers the user is forced to leave there bed to stop the alarm from sounding. The designers hope that by getting the user out of bed they will successfully wake the user and get them started on there day. By allowing the user to use their own music they can be awakened by whatever sound they want. It can be something as soothing as ocean waves or as jarring as a death-con alarm.

The designers goal was to create a device with multiple functions. We hope that the user can use this clock to play music as they go through the day, to keep track of time, and to wake them when they need to awake. By giving the clock multiple functions we make it a worthwhile investment. The designers hope that the users can also get extra use out of the removal speakers. By making them wireless the user can take them with them and use them as wireless speakers to enjoy music even while they are around the house. This will also give them the ability to have the alarm go off through the speakers when they are not in the same room as the clock.

Automation is another goal of the designers. Through the internet we hope to allow the user to set up the clock to automatically adjust date in time when connected. This way after the power comes back on from a power outage it is great for the clock to automatically reset the time and its alarms so that the user doesn't have to remember to reset them. This way the user will not miss deadlines because their clock was wrong or their alarm did not go off. Through a web application the designer hopes to give the user an easy way to interface with the device and change settings.

The quality of sound is an important aspect of this product. It is pointless to have a MP3 player that does not sound good. The best way to enjoy your music is loud and clear. By using high quality speakers and amplifiers we can achieve crystal-clear sound. This way the user is getting the most out of the MP3 player integrated into the clock. Since each speaker is its own entity they will both have there own amplifier allowing you to use each amplifier and speaker to the fullest. Making the quality of each element as high is possible is a goal that the designers hope to achieve.

# 2. Specifications and Requirements

## 2.1. Hardware Specifications

The Hardware Specifications deal with two major portions: The spring-speaker system and the size of the total device. The details were decided by the designers after careful consideration of all the variables that could come into play. Most of the specifications were logical in nature, such as the length of the device. No one would want an alarm clock, exploding or not, that is over twenty inches in length.

- The length of the total device will be longer than ten inches but no longer than twenty inches.
- There will be three outputs (speakers) for the sound. One on the left, one on the right and a speaker in the base station.
- The speaker in the base station will run the length of the base station, at the bottom.
- The two (left and right) speakers need to be the same size, and have to be smaller than the central area. A length of more than two inches but no more than 5 inches has been decided on.
- The central area needs to be longer than the speakers are. The panel that displays the time and such will be on the central area, so the base needs to be long enough to display that comfortably, as that is where the display panel that displays the time will be. Greater than five inches, but no more than ten inches is the size of the base station.
- The speakers of the alarm clock will be powered by rechargeable batteries provided upon “purchase” of the device.
- The alarm clock will have the ability to recharge the rechargeable batteries when the speakers are attached to the base of the alarm clock, and will do so without any input from the user.
- The spring system that propels the alarm clock will be a part of the main alarm clock body.
- The speakers of the alarm clock will be housed in a secure material, strong enough to keep the contents on the device safe from any damage that might occur during the landing process.
- The entire alarm clock will be housed by a material that is light enough to make the system easily moveable by the user and so the launching process
- The spring system will be powerful enough to propel the speakers at least one foot away from the base.
- The speakers will work wirelessly up to twenty feet away from the main alarm clock body.
- There will be no more than 7 dials, switches, and knobs on the alarm clock system.

- The display on the base will display no more than thirty “characters” at any given time.
- The entire alarm clock device will be controlled by one microcontroller.
- The music storage interface will be handled by a MP3 decoder that is interfaced with the microcontroller.
- The Human Machine Interface (HMI) will be handled by the buttons on the base of the alarm clock and by a remote.
- The launcher of the device needs to be usable with the user doing as little as possible to set it up (other than the normal setting of the alarm clock).
- The microcontroller needs to be able to signal the alarm clock to launch the speakers on its own.

## 2.2. Software Specifications

The majority of the Software Specifications deal with the system’s interactions with the microcontroller. The designers want the microcontroller, as it is the brains of the operation, to handle the majority of the functions of running the Exploding Alarm Clock, be it the MP3 handling or sending the signal to launch the speakers when the alarm goes off. They also want the system to function with as little interaction from the user as possible and the specifications reflect that.

- The alarm clock will need to be programmable when the user is away from the base.
- The Web Application will have the ability to automatically set the time on the alarm clock, so that in case of a power loss, the clock will be automatically reset when power is restored.
- The firmware for the microcontroller will be written in a way so that it will be able to handle all of the functions.
- All of the HMIs will be written as interrupts into the microcontroller firmware.
- The Web Application will provide a simple graphical user interface, so that even someone unused to common web technologies will be able to aptly use it.
- The microcontroller will also be programmed to handle displaying the clock time and other visual processes.
- The microcontroller will be programmed to accept data from the internet connection and use that data to change the clock time and to set the alarm time.
- The microcontroller will be programmed to trigger a series of mechanical releases.
- The microcontroller will need to be able to take the information from a decoded MP3 and transmit the information to the speakers, be they connected or detached.
- The microcontroller will be able to transmit the track data from the MP3 to the display.

- The microcontroller firmware will be required to fit within the space allotted in the microcontroller memory.

## 2.3. Block Diagrams

The following are the block diagrams of how the designers would ideally want to set up the Exploding Alarm Clock **Figure 2.3.1**. The block diagrams depict how the speakers connect to the main base station. The block diagrams also show which parts can be considered related to each other by how they are grouped.

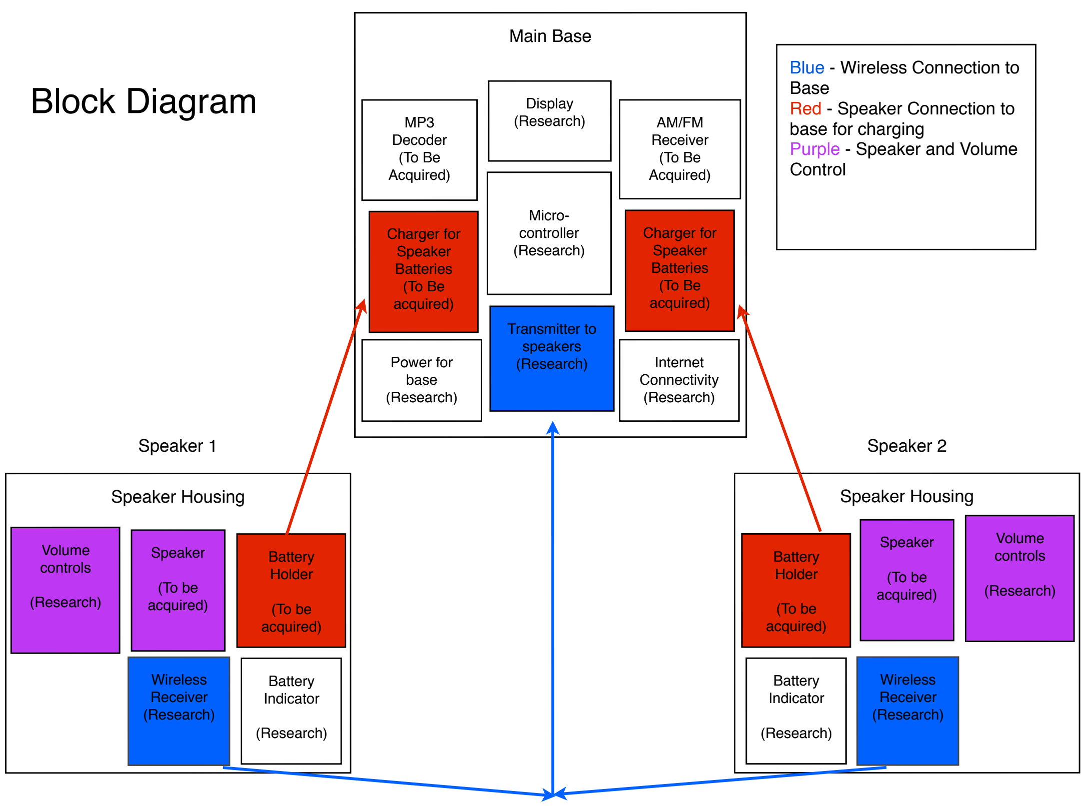



**Figure 2.3.1**

The designers decided to split up the administrative duties in a way that corresponds with what they had any experience with **Figure 2.3.2**. The duties are also split so that they grouped with the part of the system they are involved in (i.e. all the speaker related duties are grouped together).

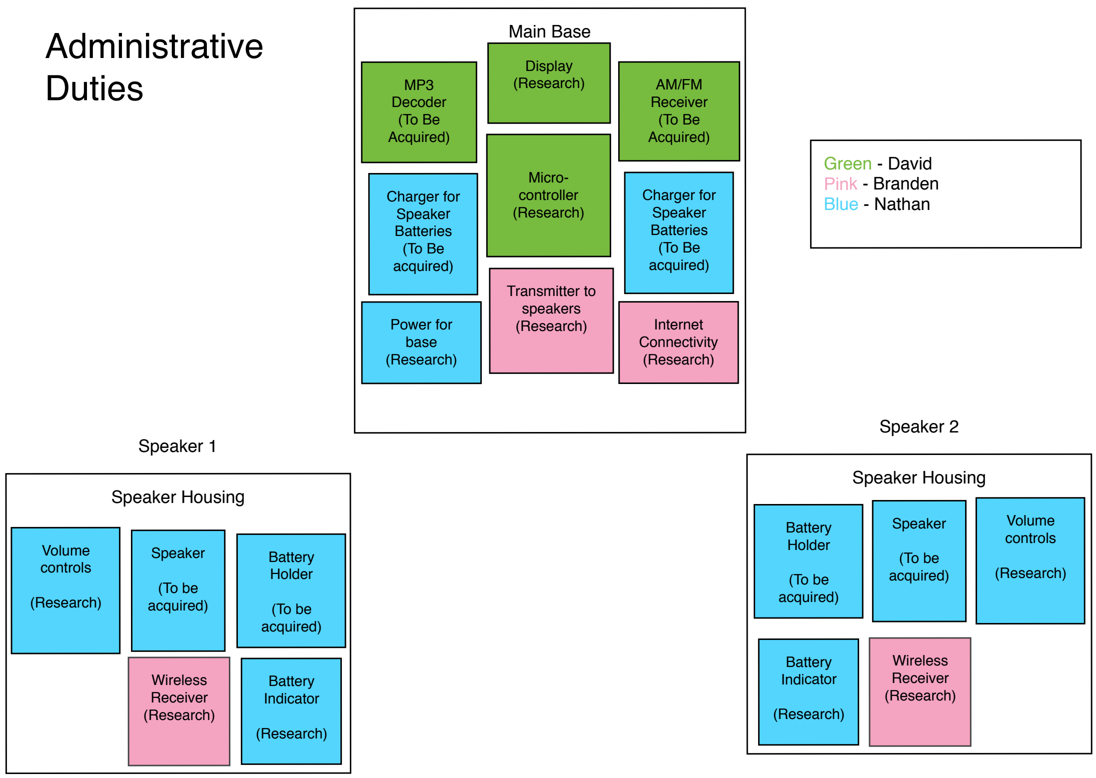



**Figure 2.3.2**

# 3. Estimated Project Schedule

The follow milestone charts were created before the designers had worked out the details of how the Exploding Alarm clock would work. As far as they knew, this would've been the most efficient way to get this project done.

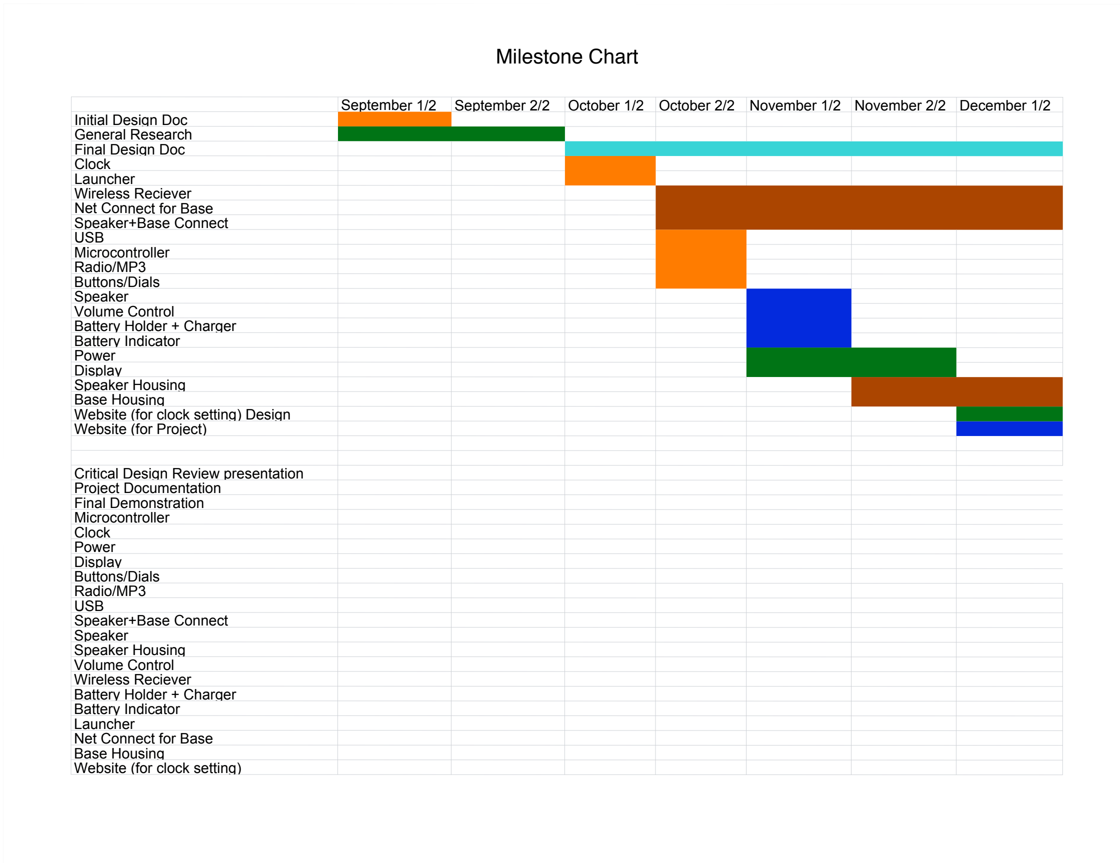



**Chart 3.1**

# 4. Estimated Project Budget

| | Finance Document | | | |
|---|---|---|---|---|
| | **Part** | **Cost** | | |
| | Speakers | $10 | | |
| | Wireless Technology for speakers | $70 | | |
| | Internet technology | $20 | | |
| | MP3 Decoder | $20 | | |
| | Display | $10 | | |
| | Housing | $30 | | |
| | Micro-controller | $50 | | |
| | Power Supply | $20 | | |
| | AM/FM Radio | $10 | | |
| | | $240 | | |
| | | | | |
| | Budget | $300 | | |
| | | | | |
| | This project will be paid for out of the group members pockets. All cost will be divided equally. | | | |

**Chart 4.1**

# 5. Research

## 5.1. Clock

The most simple, yet extremely important feature of an alarm clock is the actual clock. In order to get this clock to work properly a number of components need to effectively interface with one another to create the final clock display. The time keeping frequency could be taken from the power source, converting to the correct amount of hertz per second to account for the seconds for the clock. However, this is not the most accurate solution, so this will not be researched or used in the final design. A more accurate way of dealing with the time keeping is to use a Real-Time clock chip. Some of these chips even have a built in crystal to aid in keeping the accuracy of the oscillation eliminating the need to have an external one attached. This would be the preferred method as it cuts down on the number of parts in the design and reduces the overall complexity of the system. Some microcontrollers include a real-time clock, so they would only need a crystal added to the circuit to keep time accurately. This feature is not included in all of the microcontrollers that were researched so it can not be assumed that this will be the case. Therefore two different cases will be considered for research to account for the possibilities in the final design. The first being that the microcontroller does not include an internal clock and needs an external clock IC and the second is where the microcontroller features an internal clock. The first case's research involves finding a part that would fit in to the design of the project while providing the ability to keep time. There are a number of different ICs that include all of the needed components for running the clock.

**DS1307:** This particular part is used in conjunction with a crystal oscillator to handle the time keeping for the alarm clock. The part is added to the system connected to the microcontroller's $I^2C$ port to send the time through I/O pins. The part has many features that are desirable in the final design of the alarm clock and some of these features are listed below.

- Real-Time Clock (RTC) Counts Seconds, Minutes, Hours, Date of the Month, Month, Day of the week, and Year with Leap-Year Compensation Valid Up to 2100
- 56-Byte, Battery-Backed, General-Purpose RAM with Unlimited Writes
- $I^2C$ Serial Interface
- Programmable Square-Wave Output Signal
- Automatic Power-Fail Detect and Switch Circuitry
- Consumes Less than 500nA in Battery-Backup Mode with Oscillator Running
- Optional Industrial Temperature Range: -40°C to +85°C
- Available in 8-Pin Plastic DIP or SO

The low power device would be a good asset to the design of the project, but the schematic design needs to be considered in order to integrate the part. The basic schematic design for this part is provided by the developer website and can be

seen below in **Figure 5.1.1**. The figure shows how it would be interfaced with a microcontroller, depicted as the CPU in the diagram, and what other connections need to be made to get the part to function.

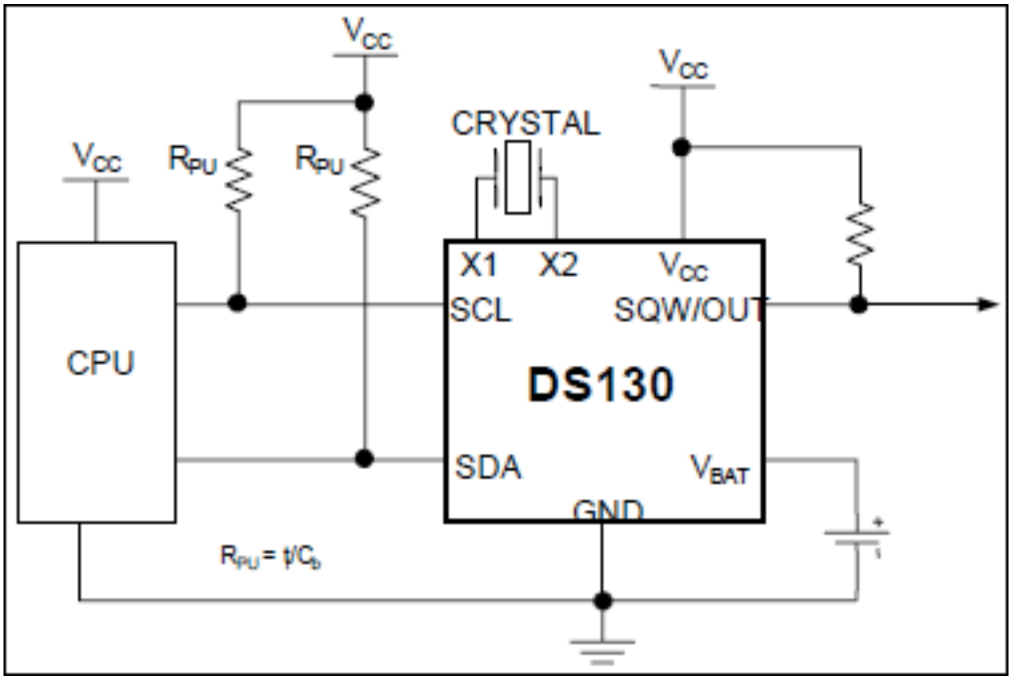



**Figure 5.1.1**
(Reprint with permission from Maxim)

The cost of this part also needs to be considered when deciding a final part. The price for this particular part is a little high, between $4 and $5, as far as RTCs go. However, the features and the ease of implementation because of the simple data sheets and application notes help its case. Integration of this part has some dependence on the microcontroller that is chosen. If a microcontroller with a built-in real-time clock is picked then this part would be unnecessary. However, if that feature is not included this would be a good candidate for choosing the final real-time clock controller.

**M41ST84W:** Another real-time clock chip that is under consideration is from STMicroelectronics. This particular chip is an I²C serial chip that would be used along with a crystal oscillator. The features that are included with piece would help in the design of the alarm clock, mainly the built-in programmable alarm with interrupt. Some other features that are included are in the list below.

- 400kHz I²C serial interface
- 44 bytes of general purpose NVRAM
- Counters for time and date
- 32kHz oscillator with integrated load capacitance (12.5pF)
- Package is a 16-lead SOIC

With these features and the correct schematic implementation, the alarm clock, both alarm and time keeping, could be handled. The functionality of the part and

the combination of a quartz crystal oscillator would add simplicity to the overall design. Along with the features that it offers, the cost, which is between $2 and $3, needs to be considered when selecting a part to be implemented. The next part that needs to be explored is the needed addition piece for microcontrollers with built-in real-time clocks.

**Crystal Oscillators:** The crystal oscillator helps compliment the real-time clock circuit by offering a precise frequency to provide a stable clock signal. The real-time clock, whether it is built-in to the microcontroller or a separate $I^2C$, needs a constant frequency so that it can get an accurate time from the frequency. The seconds are derived by dividing the frequency till you get 1Hz per second, and then using variations to get the other time components. The crystal oscillators come in small packages with two pins that can be connected to the circuit to send the frequency. The price varies depending on the package and the frequency desired, but it can vary from $1 to $15. They are a simple component to the system, but very important if accuracy is desired. The frequency needed depends on the microcontroller or part that is picked, but this will be explored more in the design section of the clock.

## 5.2. Display

The display is probably the most important part of the clock. For our design a digital display of some sort is the most sensible. It will need to be able to display time as well as other information such as a selected song since the clock will also function as a mp3 player. Without out the appropriate display many of the features of this clock are pointless.

**Seven Segment Display:** Seven segment displays are the most commonly used displays in digital clocks. The provide the ability to display digits zero through nine and a the letters a through f. This display is perfect for just displaying time but it lacks the functionality we need for our design. It lacks the ability to display all the letters in the alphabet or special characters which are common in song titles. Its also doesn't have the ability to show current clock functions that we will have like displaying what input the radio is using, if its a.m. or p.m., or if there is an alarm set.

**CFA-635:** Another display option is the Crystalfontsz CFA-635. With is on built in micro-controller, buttons for selecting options, free software for programming, and built in backlighting it provides many options. It displays twenty characters and for lines. This includes letters numbers and special characters it is also capable of displaying graphics. The micro-controller include in this display is completely reprogrammable allow us the freedom to use it for our purpose. The only difficulty this may provide is interfacing it with what ever micro-controller we use to control the main functions of our clock. Mounting brackets are also available making it easier to build into the design of the clock. Customization of

firmware and hardware are also available from the factory. The CFA-635 is shown below in **Figure 5.2.1**.


**Figure 5.2.1**
Reprinted with permission from Crystalfontz

**SC2004:** Another viable LCD display is the Silicon Craft SC2004. It is a 20x4 character display available in three different color options. The SC2004 has built in flash memory allowing you to program and store user defined settings and custom characters. It also allows you to display big numbers. This is great for the clock function. By setting it display big numbers after a certain amount of time or when not playing music it will look like a normal clock. The display uses a P3 serial interface to control it. Free software is available for testing the display and for creating custom characters. All display commands are simply hex codes readily available in the user manual. There are 3 digital outputs and 3 active low inputs also built into the display. The digital outputs give us the ability to to use a cursor to select something on the screen and send the selection out from the display the main micro controller.

**Touchscreen:** A touchscreen would be the most flexible option of all. It would allow for many different things. With a touch screen we could eliminate the need for any other buttons on the clock. We could use softkeys within the display to do everything. The downside to the touch scree would be the increased amount of programming needed. The reliability of the whole system on that part also increases. If something goes wrong with it then there is no way to do anything with the clock. Another pro of the touch screen is the ability to display just about anything we want such as song information, CD covers for songs if they are available, time, and other important information. The main downfall of a touch screen is cost because of the high cost we have to worry about something going wrong with it. If something does go wrong with it or it breaks we may not have the funds to replace it.

## 5.3. Internet Connection

One of the features the exploding alarm clock is going to have is the ability to be set by the user when the user is not home. The only viable way of accomplishing this is by connecting the main base of the alarm clock to the internet. This section will not discuss the actual program that sets the clock (see the WebApp section for more details on this) but will discuss the possible methods for connecting the

alarm clock to the internet. There are three possible methods that were thought of: 1) having a wireless card inside the base of the alarm clock (Wi-Fi) 2) having a bluetooth connection between the base of the alarm clock and the user's home computer 3) having an Ethernet connection on the base of the alarm clock.

**Wi-Fi**: Using a wireless internet connection to connect the alarm clock to the World Wide Web for on-the-go alarm setting has some pros and some cons. Wireless networks are relatively easy to set up as they are not any more difficult than a normal network. They would require the user to have a wireless router, but those can be found at local stores for relatively cheap prices. New consumer appliances like the Apple iPod, netbook computers, Pocket PCs, printers and even DVD players are able to connect to wireless networks in the user's home. Knowing that, many of the difficulties in letting the alarm clock connect to the internet through a wireless Wi-Fi connection have already been solved by many companies and manufacturers. The distance for a working Wi-Fi connection is different for every router, though most routers provide about one hundred feet of unblocked signal. As long as the user kept the alarm clock within that distance from the router, the alarm clock would be able to recognize the network and connect to it.

The alarm clock can be connected by having a wireless card installed inside of it (which would require that whatever housing is used does not block or distort the signal in any way), or by using one of the USB Wi-Fi dongles that would attach to a USB port on the alarm clock. A wireless card can be bought for relatively low prices as can USB dongles. Both average around twenty-five dollars. A company called Lantronix makes a device that can attach onto a microcontroller in an embedded system and allow it to have wireless capabilities. While designed more for using the web in a casual fashion, this would work very well inside the exploding alarm clock. It is pricey, however, with a MSRP of $299.

There are some serious questions to consider if a Wi-Fi connection is chosen. Can the alarm access secure networks/would the user have the ability to input the password for a network? If not, the user would have to be working with an unsecured network would could leave their computers vulnerable. How are the different networks displayed? The more complex/numerous the display data required, the more expensive a LCD that display it will be.

**Bluetooth**: Another possibility is having a Bluetooth connection between the base of the alarm clock and the user's computer. A "pro" from Bluetooth (that also applies to Wi-Fi) is the lack of wires. Other than the Bluetooth receivers and transponders, there is no other connection required. Bluetooth can send data at a max rate of 3Mbps according to the article

How Bluetooth Works on howstuffworks.com. 3Mbps will be more than needed, but its good to know that all the data that would be needed to be sent to the alarm clock could be sent in a mere moment. A Bluetooth signal is moderately weak, compared to other electronic devices. It is able to project its signal up to

about 32 feet. One would assume that the user's computer would be in the bedroom or in the room next to the bedroom, so 32 feet should be sufficient enough to cover the distance between the alarm clock and the computer.

An interesting aspect of Bluetooth is that up to eight devices can be connected simultaneously. This will only be useful if the speakers end up being connected to the base via Bluetooth. That way the alarm clock can be designed with the two connections between the speakers and the alarm clock base, and then have the connection between the base and the user's computer without worrying about any data being lost or misread (with misreading meaning data meant for the speakers being sent to the computer or vice versa). On that same thought, security can be part of the Bluetooth package as well. Bluetooth devices can established trusted relationships with other devices and only accept data/send data to those devices. Unlike other Bluetooth related devices, if used in the speaker system, the "accept or deny data transfer" method to security would be a hurt, not a help. It would keep the user from being able to set their alarm clocks from an away-from-home location and from listening to music in a carefree manner.

A Bluetooth connection is also an automatic connection so there would be no worries that the user connected to the wrong network, or that they did not set up the Wi-Fi connection correctly or anything of that nature. Bluetooth is also relatively low powered. This will work well for the base of the alarm clock, as there will be no worries about the drain on the user's electricity bill due to some power hungry system. There are things like shoe sole wear-out sensors and GPS shoes that are in the works according to an article on  bluetooth.com called Experience Wacky Applications, Bluetooth enabled stethoscopes, Bluetooth enabled dresses (that light up when the user gets a call) and more are also out there, so the power drain of Bluetooth on any system can be made very, very small as evident by these devices.

**Ethernet**: The final viable method for an internet connection for the base of the alarm clock is an Ethernet connection. Ethernet is the default method of internet connection for computers and other stationary internet ready devices. As Ethernet is a wired technology, the distance between the user's modem or router and the base of the alarm clock is limited. Most Ethernet cables are going to be a few feet long, though there are some that are made longer. This limit would mean the user would have to have their router in the same room as their alarm clock. The Ethernet connection would treat the alarm clock as just another computer device connected to the network.

There would be no worries about data being lost between all the connections, since the speaker connections are a wireless technology and the Ethernet is a wired connection.  There is not any way for the speakers wireless connection to interfere with a wired Ethernet connection the same way that having them all being the same type of wireless connection can theoretically cause. An Ethernet

connection is going to have good security as there is no way of someone outside of the household (hacker of some sort) to interfere the same way it is theoretically possible with wireless technologies (like Bluetooth and Wi-Fi).

Fortunately for the design of the alarm clock, almost all microcontroller companies have some form of an Ethernet shield that allows there microcontroller to connect to the internet via an Ethernet connection. They are easy connections that are built for the specific microcontroller. This is helpful because it means if Ethernet is decided upon as the way to connect to the internet, then nothing should have to be changed in the microcontroller department to accommodate this choice.

## 5.4. Power

Every device built needs to be powered in some way. The power source chosen needs to be efficient and stable. If the power supply is not stable enough and the clock loses power frequently the user will never have the correct time and will constantly have to reset their clock to the appropriate time. This is not ideal in a clock. Ideally you want your clock to never lose power. So that no matter what happens when you fall asleep your clocks going to have the right time and your alarm is going to wake you up when you want it to.There are many ways to achieve this and some possibilities will be talked about below

**Batteries:** One of the most common ways of powering an electronic device is batteries. This mainly for portability. Batteries are easily replaced and allow your device to function even during a power outage. There are many different battery options and they are available both rechargeable and non-rechargeable. Since we are going to be using many different functions with this clock this is not the most efficient way to power. The speakers are planned to use rechargeable and will use the main base as a charging station so the will draw a great amount of power. The main base will also charge whatever device its is playing music from so that the users device won't have a dead battery every time the need to use it after using it with their clock.

Although not the most efficient way to power the whole system batteries aren't such a bad thing to have. Bye including batteries as a backup. This could save many users from waking up late do to a power outage. It is very common that a power outage and a person loses their all there clock setting such as alarms and times. By backing up the systems power with rechargeable batteries we can protect the users from this occurrence. This is also nice for if you want to move your clock to another location in the house. You can just unplug it move it to where you want it and then plug it back in and you do not have to worry about resetting it.

**Photovoltaics:** A readily available power source is the sun. Pumping tons of energy to earth every day it is a ample power supply for a clock. Photovoltaic cells are very common currently amongst people trying to go green. It is a very clean power source. Although great for electrics cars and many outdoor items its is probably not the best way to power a clock radio that is mainly meant for home use. It is possible to use photovoltaic cells to charge a battery that will power the clock but from a designer prospective this isn't the most cost effective method. It would also create more complicated circuitry.

If we were looking to create a self sustaining clock that a person could take anywhere this is probably the best option. The clock would be completely portable and you would almost never have to worry about how to power it or worry about changing batteries or finding some where to plug it in. As long as there was some sort of sunlight you could basically power the clock anywhere.

**AC Power:** The easiest and probably most straight forward way to power the device is AC power from a wall receptacle. This is the most common way that house hold appliances like a clock are powered. The complication from this comes in when distributing the right voltages and currents to parts. Aside from this there are really no downsides to this. The power received from a wall socket is stable and constant. As long as the user has power in there house they don't have to worry about the clock cutting off.

AC Power adds the least additional cost to the project. The power source is the wall receptacle. This is an external power source that is already in place in the users environment. The parts need for the circuitry involved with interfacing this power supply are very common and inexpensive. This will making getting them all together an easy process.

In order to make the clock if more efficient we have the option of combing an of these ideas for power. A common example is the combination of AC power and batteries. With this even if the user loses power in their house they clock will still function until the batteries die. This also allows the user to unplug the clock and move it to another place. During this move the clock will stay on and it won't lose any information. It also gives the user the ability to take the clock with them somewhere if needed and they won't need to find some where to plug it in.

## 5.5. Alarm Clock And Speaker Housing:

**PVC**: PVC was one of the first materials thought of as housing for the project. It is the engineering do-all material. PVC is a very cheap material, current prices as of this writing, put it at about eleven dollars for a one foot by two foot, quarter-inch thick sheet. PVC is a very lightly weighted material. The aforementioned sheet only weighs about four pounds. As shown by the last source, PVC is very easy to acquire. One need not go far out of one's way to get it. Any local

hardware store or an all-around web provider should have PVC in stock in some form.

PVC does have some downsides, however. Its ability to stand up to intense pressure is limited. Its ability to stand up to the constant slamming into the ground for a decent height is limited (the type of situation it might be applied to if the speakers are being projected off tables) onto hard floors. This has a flip side: its low strength also means there are no worries of damage to the floor by the falling speakers. PVC is also easy to shape, so there should be no difficulty in forming it into the shape of an alarm clock. But PVC is also not an appealing substance, neither in appearance or texture. It looks cheap, and it feels cheap. But more important than any of that are the health concerns. PVC is a very controversial material and whether or not the claims have any merit, a consumer is not going to want an alarm clock that could possibly hurt their reproductive systems growth.

**Metal**: Metal is an understandably generic term, but in this case its meant to be aluminum, steel and/or iron. Metal is much more expensive than PVC. For a sheet of aluminum, one foot by one foot and only one-eight of an inch thick it costs about fourteen dollars, three dollars more than a larger size of PVC. Steel is even more expensive with it costing two dollars and forty-eight cents for something that is six inches by eighteen inches but only .008 inches thick. But something that is thin would not offer the protection that one would go to metal for and to get that you would have a very heavy housing. While its increased density would give it a much needed strength to absorb the force of falling to the floor, make it too strong and it could actually damage the floor.

Like PVC, metal would be very easy to obtain. The local hardware store and online stores like amazon.com would be the easiest places to find it. Unlike PVC, metal will be a bit harder to shape, because of its difficulty to cut. But it would look nice, as the metallic look is very slick. So it would be appealing to the prospective users to have a metal housing for the alarm clock. A final, and probably most important, point is the fact that metal blocks signals. The speakers and base are going to wirelessly communicate with one another and having them the transmitters and receivers in a metal base may greatly diminish their range.

**Wood:** Wood was mostly considered because of the aesthetics of it. Wood can be shaped and formed very easily. Having an alarm clock shaped out of wood would be very pleasing to the eye. It would give a very old-timey, retro look to the clock. Wood would be easy to acquire, as most varieties of it are readily available. Wood is also very, very cheap. A piece of dried dimensional lumber that is two inches thick, four inches wide and ten feet long is only three dollars and sixty-two cents.

But an alarm clock that has a two inch thick cover is not going to be very comfortable for a user to own. With two inches thick all around of just the

housing, it would be a very bulky device. However, the wood that a store like Home Depot would provide would not stand up to the constant dropping to a hard floor. It would eventually damage the casing and fall apart. It would not damage the room in anyway though, so that is a plus in the wood category. However, since it is wood it cannot be very safe to leave them in an environment where, under bad conditions, sparks could fly.

**Glass**: Glass is probably the least likely to be used of all the solutions for housing that were thought of. Glass is moderately expensive. The cheapest place to get them has some pretty atrocious shipping costs. What would normally be just a couple of dollars for a few square footage of glass at .1 inch thickness increases a lot when trying to ship anywhere long distance. Local stores sell glass, but it is much more expensive, and it is not in usable quantities. Glass is not as light as PVC is or as wood is either. It would be more difficult for the user to move this alarm clock or carry around the speakers. And that makes it harder to see glass as a viable option if it becomes cumbersome for the user. The transparency of glass does increase its appeal, as see-through objects are very popular.

Glass would be very difficult to mold it to an alarm clock shape. Someone with extensive training would need to be found to shape and cut the glass, and their services would not come cheap. And more importantly that that, glass would not work for the speakers. If someone was to drop something glass from their table, it would crack, it would shatter and it would break. This alarm needs to be made to handle more than one time going off.

**Plexiglas**: Plexiglas is a material with a glass-like transparency, but without the weakness and extra weight. Plexiglas can be easily bought from local retailers (though their selections might be small) or from online vendors. A sheet of Plexiglas one foot by one foot and 1/8 of an inch thickness goes for twenty dollars. Plexiglas is the material used in WWII era planes to protect the pilots from bullets, according to Plexiglass Primer, so it should definitely be able to handle being knocked to the floor every day. Plexiglas is half the weight of glass , so it is very user friendly. Not only that, but the light weight would make it good for preventing any room damage from the falling speakers. And because of its glass-like transparency, it has all the benefits associated with being see-through. Plexiglas also has the ability to withstand very high temperatures, which is perfect for something that will be handling electrical parts in close proximity to one another.

The one negative aspect of Plexiglas is its ability to shape. While not as difficult as attempting to reform metal, Plexiglas has the strange ability to crack if cut too slowly (say with a jigsaw) or to have the edges start to melt if cut too quickly. It would either take multiple attempts to figure out the perfect speed, or someone would experience with cutting Plexiglas could be hired/volunteer their time.

**Polycarbonate**: Polycarbonates, like Plexiglas, are a form of thermoplastics. Polycarbonates have all the "pros" of Plexiglas, and in fact, have better versions of those "pros". One of the brand names, and the most common form of a polycarbonate, is called Lexan. Like Plexiglas, Lexan is very impact resistant. Lexan is able to absorb "the equivalent of 4300 pounds of TNT detonated from 115 feet away". Anything that can easily withstand TNT should be able to handle dropping onto a tile floor and/or being hit with the spring system everyday. In a more common use, Lexan is used in vending machines. That is what the formerly glass cover is made out of.

It is also flame resistant, which is very good when it comes to housing electronics. Not that the alarm is expected to actually catch afire, but it is good to know that it can handle any extreme heat that may be generated by the electrical parts that make it up. Lexan is also relatively cheap. At Amazon.com, one can get a one-fourth inch thick, twelve inch by twenty four inch piece of Lexan for a little over twelve dollars. Compared to the prices of Plexiglas, that is a great deal. Lexan is also just as easy to obtain as the Plexiglas; it can be found at many retailers online and at local home improvement stores.

Because Lexan is transparent, like glass and Plexiglas, it will have all the see-through benefits talked about earlier. But unlike glass and like Plexiglas, Lexan is a light material, so there are no worries about it being too big or too bulky for the common user. And because of Lexan's strength, thinner pieces of it can be used while still achieving a high impact resistance. Lexan is also safe in all environments. Underwriters Laboratory approved Lexan for use in electronic devices and Lexan meets the FDA's requirements for use with food and in the home.

## 5.6. Radio

A minor, yet important component of the design is the radio for the alarm and casual listening. Even though radio is not the most popular music listening choice it is still an expected feature of an alarm clock, so it will be added to incorporate a larger audience of consumers. There are a number of available options for using a radio frequency tuner to implement a radio into the design.

**LV24003LP:** One of these options is the LV24003LP single-chip FM/AM tuner IC for portable electronic devices made by Sanyo Semiconductors. This particular device comes with a number of desirable features that are listed below.

- No external components are necessary
- Fully integrated low IF selectivity and demodulation
- Very high sensitivity due to integrated low noise RF input amplifier
- Low power Standby mode
- 3-wire bus interface including Data, Clock, NR-W

This particular chip is made for mobile device applications but it could be transferred to the design of this project in an easy way. Omitting some of the

unneeded features such as buzzing and the headphone amp could be easily done by ignoring the pins and not incorporating it into the design. The main hesitation of this chip is if it does not implement as well as a non mobile chip. However, looking at the schematic design for the chip in the data sheet shows promise to the ease of implementation into the final design.

**LA181:** Another chip that could be considered is very similar to the previously described chip only this one is not specifically for mobile devices. It is made by the same company and is called LA181. It has the same features as the other chip, except for the lack of built in mobile applications. It also is an older chip, but it is simple in its design and implementation, which could be helpful in interfacing it with the rest of the design.

**SPK-TFM-1010:** This part is a breakout board from SparkFun electronics that is based off of the AR1010 integrated circuit from Airoha. Some of the basic features included in this part are listed below.

- 3.3V @ 11mA
- 76-108MHz supported
- 100mV audio output
- Stereo output

This part has some pros and cons that are at very significant ends of the spectrum. The pros of this part are that it is a small chip that can be easily integrated into the design with no additions other than an antenna and that it can use a simple command set over $I^2C$ or SPI interface. The chip also has the benefit of allowing direct connection of audio output, because all of the needed components are contained on the breakout board. The two main cons for using this board is that it does not include functionality with AM and the cost is relatively higher then the other chips that were researched. The lack AM radio functionality is not the biggest of downfalls, being that FM is more popular of a choice. The cost is also manageable at a $10 price tag. So, overall the pros out way the cons making this part a good candidate for the final design.

**TA8127:** One last chip design to consider is the TA8127 by Unisonic Technologies. After researching all of these different tuner chips it is apparent that they are all extremely similar. As a result, the TA8127 has about the same features as the other two. The interesting feature of this chip is its low operating supply voltage of 1.8V. Deciding which tuner chip to use is a matter of ease of integration with the rest of the design, and cost. The amount of features is not a factor in part selection because of the lack of extra features that could be added, so in other words, the bare minimum is all that is needed. The tuner is not the only thing we need to complete the FM/AM circuit. The antenna is what picks up the signals to send to the tuner and is therefore crucial to the circuit. The antenna finds the modulated sine waves in the air and sends them to the receiver so that they can be demodulated and converted to playable data. The antenna is simple, yet important to the radio's design because with out one the receiver would not be able to pick up the modulated waves unless it was close to the transmitter. An

antenna can be a simple stick of metal that is attached to the antenna-in port of the module. However, for this design a simple radio antenna purchased from any electronics store will be sufficient. One example is the Pyramid 3800 AM/FM antenna, which is around 10 dollars. One other thing that needs to be added is the HMI for the radio control. The HMI is discussed in the MP3 decoder sections and the same information can be applied to this section. The only difference is that it the controls will be tied to the radio instead of MP3 controlling. Choosing the parts for this design is as simple as picking a simple part that is easily implemented into the design.

## 5.7. MP3 Decoder

A key component to the Exploding Alarm Clock design is the ability to play MP3 music files as the alarm and for casual listening. In order to do this the MP3 files are taken from the mass media device and passed to the MP3 decoder so that they can be decoded and passed to the digital to analog converter and then on to the speakers for output. The reason this is necessary is because MP3 files are encoded in lossy data compression so that the files are smaller. The storage of the files becomes smaller because of compression, but they need to be decoded when being accessed for playing. The MP3 decoder is implemented through an MP3 decoder chip, or MP3 decoding software on a programmable chip such as a microcontroller. There are a few possible options for MP3 decoding for our design.

**AT32UC3B:** The first involves using the AT32UC3B chip, which is further described in the Memory Storage and Interface section. This microcontroller chip would enable the interfacing of USB and SD cards as well as implementing an MP3 decoder in software. The great thing about implementing the MP3 decoder in software with this chip is that the software already exists on the developer's website in an application note. Modifications would have to be made but the general layout and decoding is already coded. This would ease the pain of writing a decoder from scratch which would be very difficult because of the extensive knowledge of the encoding process of MP3's that would need to be known. Some of the things that would need to be added in order to make the MP3 decoding process complete include adding a user interface code and parts for playback selection. Although this is not exactly part of the MP3 decoding process, it still is important to give the user the option to select which MP3 to play, and also give a play pause feature. Using the AT32UC3B for MP3 decoding would give us the option to add buttons to the general input/output pins and modify the software code to use these inputs as playing commands. Another option would be to send the data to the main microcontroller and attach the user commands to that microcontroller instead of the one that does the MP3 decoding. Regardless of the actual routing of the data, the user needs to be able to have the control over the MP3 data being decoded. The different kinds of user input devices will be discussed at the end of this section, after other MP3 decoders are reviewed.

**VS1033:** Another MP3 decoder that shows promise is VSLI's VS1033 MP3 codec IC. This particular chip has some very interesting features that would make it a powerful addition to the design of the alarm clock. Some of these features are listed below.

- Built in decoder for MP3/AAC/WMA/MIDI
- Streaming support for MP3 and WAV
- Bass and treble controls
- On-chip stereo DAC with no phase error between channels
- Available interface for external DAC
- Software to edit the 8 general purpose input/output pins
- Low-power operation, including separate operating voltages for analog, digital and I/O

Implementing this chip would be easy enough, because it just receives the data from the storage device and then passes on the decoded information on to the speakers, because of the on-chip DAC. The on-chip DAC would probably be sufficient for the digital to analog conversion so it would replace an external chip reducing the amount of parts needed in the final design. It would also be wise to consider this chip because of the different formats that it is capable of decoding, which give the consumer more of an incentive to purchase because of the versatility.

**BU9438KV:** Another worthy component is the BU9438KV by Rohm Semiconductor. This chip is very versatile much like the VS1033 because of its ability to decode a number of different formats. What sets this chip apart is the built in function of reading from USB and SD. This would eliminate the need to come up with another interface for memory storage and cut down on parts needed. There are a number of features that would be useful to this design that are included in the BU9438KV arsenal. Some of the features are listed below.

- USB and SD memory audio play function built in
- USB 2.0 Full-speed host controller contained
- SD memory card controller contained (SD/SDHC/miniSD/microSD/MMC)
- Decoder included for MP3/WMA/AAC
- Integrated LDO to eliminate the need for an external core power supply
- Integrated PLL to eliminate the need for an external crystal
- On-chip DAC
- Built in LED support

The chip comes in a VQFP64 package, meaning it has 64 lead pins. The data sheet provided by the producer website is very simple and easy to understand which helps in the choosing process because some of the data sheets for the other options are full of unnecessary data making them more difficult to decipher.

**STA013:** One last MP3 decoder that could potentially be used in the final design is the STA013 Chip. This chip is older compared to the other chips that have been researched, but that also helps with the amount of examples available on the internet. The chip just has the standard MP3 decoding option and needs to

be configured with an external DAC in order to do the proper conversions for audio playback. The main reason to use this particular chip would be to keep it simple. The chip has the bare minimum for MP3 decoding and is very simple to implement. Obviously the user might like the choice of having more then just MP3 for a file format choice, so this chip may not be the best choice. Also, the fact that the other chips looked at have such features as built in USB and SD interfaces, as well as a built in DAC could lead the project to use a different decoder for the final design. Simplicity is not always the best way to go when thinking about marketing a product, because consumers always want the latest and greatest with the most features. The part selection process will take in all of the factors, such as cost, features, ease of implementation, and ease of user interface integration, in order to pick the best part for this project.

**Human-Machine Interface:** Another important part of the MP3 process is the Human-Machine interface so that the user can control the playing of the songs. There are a number of ways this could be accomplished all to the same effect, just different process. One possibility would be the implementation of buttons integrated into the circuit as switches. These switches would let the input/output pin, which are receiving a constant voltage, go to ground when ever the buttons are pushed. This would act as an event to the handler and processed depending on what the input was tied to. For example, if there was a button for the input to the play/pause button and the button was pushed, the input would go to ground and the software for the handler would interpret that as a play/pause function and then process it as such. These switches are the very basic form of user interface and therefore are cheap and easily implemented. A couple of buttons would need to be purchased so that each function could be implemented. There are other alternatives however that need to be considered. Another option is using a keypad that has all of the switches on a PC board already and can be connected to a microcontroller to send the signals for pressed buttons. This configuration is the same as the button/switch configuration just with more of them consolidated on to one board. The main problem with this is finding a non-customized keypad that would fit the amount of buttons needed for implementation. Customized keypads could be purchased but the amount of time and money spent in acquiring one does not seem worth it. A specific number of buttons is better handled by purchasing individual push button switches. The last possible solution that will be discussed is an infrared remote control. This could be implemented along with one of the other designs to enhance the user options. The Exploding Alarm Clock's overall design includes casual listening functionality with the speakers detached. The user would probably appreciate the ability to switch songs, change the volume, and pause the song with out pressing the buttons on the base. This is important because the user may not be close to the base when using the MP3 player, perhaps across the room. This could be implemented by using an IR receiver connected to a microcontroller to handle the process received. The remote is the easy part of the implementation because any IR remote can be configured to work with the IR receiver.  An IR receiver typically consists of the optical lens and 5 lead pins. An example of an IR receiver can be

seen in **Figure 5.7.1**, which displays the TSOP853 made by Vishay Semiconductors. The 5 lead pins on the bottom of the part correspond to three different grounds, a supply voltage, and a data out.

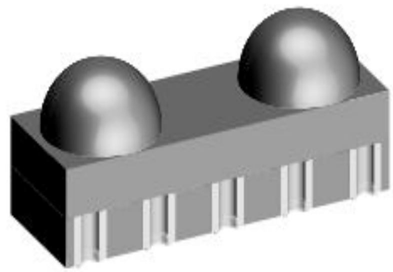


**Figure 5.7.1**
(Image courtesy of Vishay Intertechnology, Inc.)

The receiver sends the output through the data out pin to the microcontroller where it  can process the commands accordingly. These are just some examples of the user interface to the MP3 player portion of the design. The final selection process of the implementation will take in to consideration the cost, ease of implementation, user friendliness, and integration of software in the design.

## 5.8. Memory Storing and Interfacing

With the ability to play music files in place, the alarm clock will need a place where it can store the files. The key issue is to find a device interface that can hold music files and pass them to the MP3 decoder for playback. There are a few options available to us, all within consideration for the caliber of this project. These options include USB flash memory, SD card memory, and iPod connectivity and playback. All of these options would be used to store music files for playback for the alarm, and for casual listening. To clarify, iPod connectivity would be through the standard iPod cable, which ends in USB, and enable the use of the iPod as normal with the sound producing from the base and speakers of the alarm clock. They would also need a standardized convention or method to pass information to the MP3 decoder, which is technically called the interface. All of these conventions have their pros and cons and need to be weighed heavily to pick the best media for this design.

**IPod:** To start with a difficult one, iPod playback for this particular implementation seemed unattainable for this scale of project. Apple’s need to control the market for iPod related products has led them to produce an authentication chip that is required to decode the interface for the iPod. Popular Mechanics Magazine had an article about the chip and the grief of dealing with Apple’s desire to dominate the market that explained what the chip did. This excerpt is from that article, “The chip works like a silicon key that unlocks streaming video functionality on

iPhones and iPods and generally authorizes the devices to work with approved accessories. The advent of the “auth chip” made it impossible for any third-party company to produce iPod-compatible gadgets without dealing first with Apple—the only company selling the chip.”[1] This chip is bought by third party companies for a steep price, not to mention the royalties included in producing an Apple related product. An attempt was made to contact Apple in regards to receiving one of these chips for educational purposes, but the request was never answered. All designs of iPods, excluding the Touch, can be used as a mass storage device, so in reality an iPod could be used through USB to play music files. However, it would not play the files that were put on the device through iTunes, the media player for adding music to the iPod. The songs that would play are those that were manually added with drag and drop to the file system. However, there are microcontrollers found to handle MP3 decoding that claim it can be used to interface with the iPod, iTouch, and iPhone. Also, pin schematics for the standard connection to the new iPods have been found on the internet and could therefore be used to implement a connection and interface. The pin printout of the standard iPod connector is shown in **Figure 11.2.1** in the appendix**.** With the pin configuration and description, it is possible to disassemble a standard iPod connector and modify it to fit the needs of this project. However, it is important to know which pin is which so that you connect to the write ones. The pin layout for the physical connector is seen in **Figure 11.2.2** in the appendix. It shows the physical location of the pin in relation to the back side of the connector. With the ability to design a custom cable and have all of its pins mapped and described, the iPod can be interfaced to the design using a PIC microcontroller. A PIC, or peripheral interface controller, will act as an information buffer between the storage device or media player, and the MP3 decoder. These are a prime choice for interfacing because of the cost and simplicity of programming. They are programmed using any of the programming languages that are available with PIC compilers. Some examples of these are C, Basic, and Pascal. This groups strong point is in programming with C so that is the compiler language to be used if this is to be implemented. After the program is written and compiled it needs to be passed to the PIC using a programmer. The programmer will either be purchased or borrowed from the lab. There are obviously numerous other choices for interfacing out there, such as the AT32UC3B0256 made by Atmel®. This microcontroller is a very tempting choice as it would potentially have the capability of interfacing with all of the choices, iPod, USB, and SD. Atmel® also provides application notes that are sample programs to guide you through the steps of programming the microcontroller to do what you need it to do. The application note that would be pertinent to this design would not include the interfacing for the iPod, but it would not be extremely challenging to add that on to the program. The good thing about this application note is that it includes the interfacing for the USB flash drive and the SD card, so that all three of the choices could be implemented with little effort. It also includes MP3 decoding, which would cut down on the number of parts needed to implement this design. The software architecture for this design is shown in **Figure 5.8.1** and displays the flow of the software application.

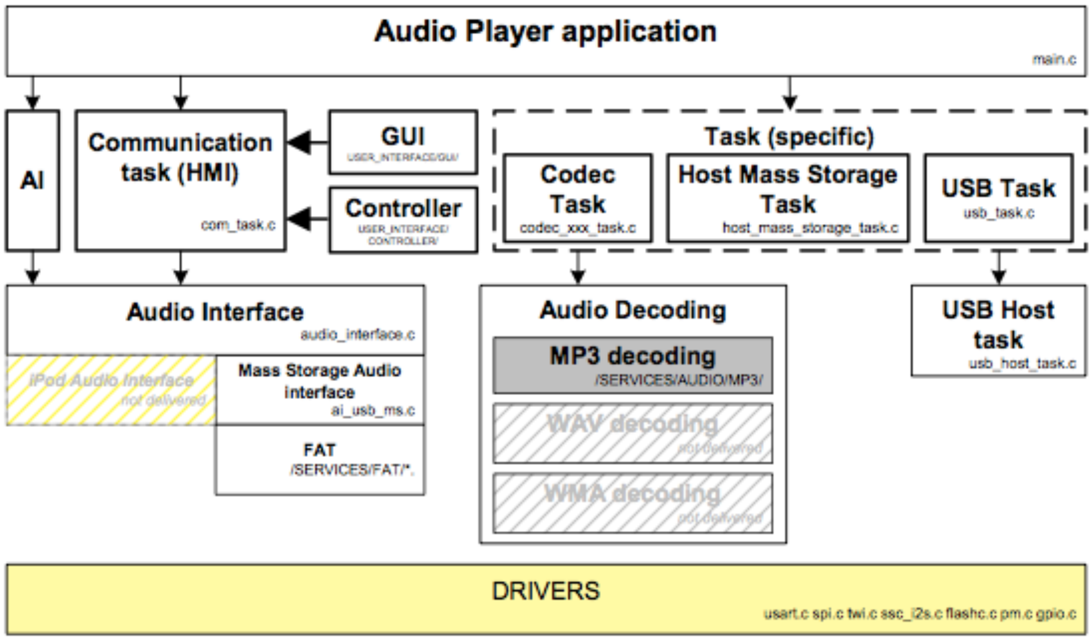



**Figure 5.8.1**
(Reprinted with permission from Atmel)

The diagram shows how the information is passed through the application including MP3 decoding and the mass storage interface. The iPod feature is shown as not delivered, but the option is available, so it could be implemented. One of the factors that need to be kept in mind when choosing which chip to interface with is cost. The cost of the PIC can range anywhere from $2 to $12 depending on the speed and amount of RAM. The Atmel® chip is around $8, but the fact that this chip would act as the interface and the decoder needs to be taken into account. Both of these options will be kept in mind when deciding a final design solution for interfacing. As a result, connection of the iPod for music playback is feasible and will be considered as an option for the music playback feature of this project, which will be discussed in the design portion of this section.

**USB:** The next option available for implementation is through USB flash memory. The implementation of a USB interface for the storing and reading of files from a flash drive would prove to be useful and user friendly, as well as allow for mass storage devices such as simple music players that use the mass storage device class along with FAT file system to be used for playing music. The selection of the MP3 decoder determines how difficult the implementation of USB flash memory would be. Older MP3 decoders do not come with the proper interface to deal with USB data transfer, but chips are now available with the interface for USB already built in to the decoder. The chips with the interface already integrated would be preferable as to reduce the number of parts and the complexity of the overall design. One step further would be to get a

microcontroller that dealt with the MP3 decoding as well as the data transfer and connectivity of the USB flash drive. These are being greatly considered as they would reduce parts, and complexity. An example of one of these microcontrollers is the AT32UC3B0256 made by Atmel®, which is described in the iPod section above this section. The Atmel® chip would be useful as it comes with the application note that includes the interface to the USB, as well as the MP3 decoder. This would be useful as it reduces the number of parts in the design as well as the amount of code that needs to be written. The code obviously needs to be edited to fit the parameters of the projects design, but the overall ground work would be there through the application note. Another solution to interfacing with the USB is to use a PIC microcontroller, like discussed in the previous section. The PIC needs to be implemented with software written to interface with the USB, which would need to include the mass storage class. Application notes could possibly be found on this to help with the coding, but it depends on what PIC you get. The Atmel® still seems like the better option for interfacing because of the features it provides. USB would seem a more logical decision for memory storage because of cost, user friendliness, capacity, lifetime, and durability. The cost of USB storage devices is decreasing while the amount of storage is increasing. Kingston just recently announced the release of a 256 gigabyte flash drive for around $900. The price may seem a little steep, but the price of smaller size flash drives has decreased as a result of the advancement in technology. This is just an example of how much the technology changes in such a short time. Now someone can buy an 8 gigabyte USB flash drive for around $15. This makes it a financially wise choice for memory storage as it is feasible to expect consumers to purchase the alarm clock and a separate USB drive for memory, if by rare chance they do not own several already. Though most consumers would find it irrelevant, USB flash drives have a high reusability in the spectrum of write/erase cycles and data retention. Some flash drives allow up to 1 million write/erase cycles which would add to the reusability of the product by allowing data to be changed numerous times. Also, most USB flash drives have ten year data retention making them last long enough without replacement. Another redeeming benefit of using USB is the transfer speeds. Even though they are not as fast as hard disks, typical drives claim a speed of 30 megabytes per second for reading. The writing is not as fast and is usually about half of the read.  This is faster then some of the alternatives such as lower end SD cards. However, SD cards have other attributes that would lead them to be a good choice for implementation in this project.

**SD Memory Card:** An interesting alternative for memory storage is the Secure Digital memory card. This memory card has a relatively low cost and high storage capacity. The regular SD standard has a storage capacity of up to 4 gigabytes. This has been improved upon in result to the improvement of the storage technology, in the form of two newer standards. The currently prominent standard is the SD High Capacity, or SDHC, which has a capacity of up to 32 gigabytes. Physically these SDHC cards are capable of capacities up to 2 terabytes, but the standard limits them to 32 gigs. This will eventually change in the recently

announced SD extended capacity standard, or SDXC, which has yet to be completely standardized and produced. Of course there are other types of SD cards such as the miniSD and the microSD, but these do not have any changes from the regular cards except for the physical dimensions and can easily be used with standard SD slots with the use of adapters. For this particular project it would be beneficial to implement the SD 2.0 standard if it were to be used as a form of memory storage. The 2.0 standard includes compatibility with SDHC cards as well as backward compatibility for the regular SD cards. The speed of the convention varies depending on the card, but can range anywhere from .9 megabytes per second for basic cards, 10 megabytes per second for some SDHC, and around 30 megabytes per second or higher for high end cards. These speeds are based on the card's maximum read times while the write times are usually slower. Using this popular implementation of memory storage would seem useful as it is already a common because of it's many other applications in cell phones, digital cameras, and game consoles. The interface is tricky part of implementation for the memory transfer, and for the SD card there are three different modes for transferring. One-bit mode is transfer mode for SD that has separate channels for data and commands. Four-bit mode uses some extra pins to send more then the one-bit mode. SPI mode is specific for microcontrollers and a more simplistic form of the SD protocol. The device for transfer will determine which transfer protocol will be used, so the final decision will be elaborated on in the design portion.  However, more than likely the SPI will be used because of the choices narrowed down for transferring. So far the main two options for the transfer are the PIC microcontroller and the Atmel® microcontroller chip described in the previous sections. These both would be easy enough to use for interfacing with the SD card. Out of all of the choices for memory storage SD cards seems to be the easiest to implement because of the sheer number of examples and software application notes out there. SD is implemented in many applications as a memory storage unit, and therefore there is a lot of documentation on how to code the interface. The most common chip used to interface with SD is the PIC microcontroller but this does not mean that the Atmel® microcontroller's implementation would be any less difficult. Because of the application note that can be downloaded to go along with the Atmel® chip, interfacing it with the SD standard is simple. Still the favor is put upon the Atmel® chip because of its ability to interface with USB, iPod, and SD. It also stands out from the PIC because it can be used as a MP3 decoder as well. If the Atmel® chip is used in the final design, it would be possible to implement all three of the memory storage choices, because of the interfacing options that come with the chip. Another interesting candidate for the interfacing portion of the memory storage units is the MP3 decoder BU9438KV made by Rohm Semiconductor. The full specification of the part is discussed in the MP3 decoder section, but the main reason it could be used for interfacing is discussed here. The chip comes with a built in interface for USB and SD card reading of music files. This would prove to be very useful as it would eliminate the need to program the chip heavily. The sheer ease of implementation makes it a very worthy candidate for implementation. When choosing a final medium for storage things that need to be

kept in mind is the storage capacity, transfer rates, cost, interface implementation, user friendliness, and durability. All of these things will be considered when implementing the final design.

## 5.9. Microcontroller

The microcontroller is perhaps the most important component of the design, as it acts as the brain. The main functions it serves are telling the other components what they need to do and handling the data flow from one unit to the next. They also provide the connection and interface between the different modules and provide the user with the ability to program it to do what ever the user desires. For the design of the project it is necessary to find a component that can handle all of the different functions required, such as, running a clock, LED screen output, and sending and receiving data in order to perform tasks such as launching the speakers and setting the time. The amount of things that need to be handled in the specific design might call for the use of more than one microcontroller to control different parts of the clock. Even though it would be possible to use one microcontroller for the whole design, breaking things into modules each with their own microcontroller might help to reduce the complexity of the overall design and cut down on debugging troubles. Before the decision of how many microcontrollers are going to be used, different microcontroller chips need to be explored to see the options and varieties that will help implement the clock in its final design.

**PIC24FJ256GA10:** The PIC microcontrollers are known for their simplicity and ease of integration into complex and simple designs. Naturally these would be explored when dealing with the selection process of the microcontroller for this project. The first PIC that was researched was the PIC24FJ256GA10 family of chips. The reason this is considered a family is because this is the general term given to the set of microcontrollers where the only difference is the pin count. The difference in pin count results in different amounts of available ports. A pin package, either 64, 80 or 100, will be chosen depending on the amount of pins needed in the final design. The chip has some desirable features that need to be put in to consideration for the final design of this project. The key specifications pertinent to the project are listed below.

- 16-bit architecture that has CPU speeds of 16 MIPS
- Program memory of 256 KB to providing ample room for the program
- For the lowest pin package: 53 I/O pins
- Built-in power managed modes for optimum low power running
- EEPROM emulation capable to eliminate the need for separate EEPROM component in the circuit design
- Supports Capacitive Touch applications incase Touch screen is implemented

The chip would support all of the needed peripherals with no problem, as well as, run the clock and other necessary functions. This powerful chip is possibly overkill for the project's needs, but this leaves no doubt that the part is capable of

handling the needed processes and functions that would be required. The chip is roughly $6 so the cost of this unit is not particularly a cause for dismissal. An alternative to using a chip that might be to powerful for the design would be to use a smaller version of the same chip. The PIC24FJ64GA series is about the same chip only with a smaller instruction memory of 64 KB. Because of the nature of the project, and the size of programming space needed, this might be a better solution. The price of this chip is smaller but only by $2, so the price difference is relatively negligible, unless you're looking at it from a business direction. Regardless of which actual chip in the PIC24FJ family is to be used, they will be greatly considered for use in the final design. The main reasons are the ease of implementation, the large amounts of tutorials and examples for PIC MCUs, and the power of the actual microcontroller. There are however other microcontrollers that need to be considered.

**AT32UC3B:** The AT32UC3B was considered for the interfacing option of the USB and SD card. However, this chip could be used in the overall control of the system. The microcontroller specifications seem to give off the impression that this part would be very capable in controlling the system. A selection of the important specifications is listed below.

- Performs at 1.38 DMIPS/MHz
- Includes a Memory Protection Unit
- 7 Peripheral DMA Channels which improves speed for peripheral communication
- Internal High-Speed Flash of 256K Bytes
- Internal High-Speed SRAM of 32K Bytes
- USB 2.0 Full/Low Speed and On-the-Go
- 64-pin TQFP/QFN which includes 44 general purpose input/output pins
- Single 3.3V Power Supply or Dual 1.8V-3.3V

The part website also provides a large amount of material on application notes and different implementation techniques that might be useful when programming the microcontroller. The data sheets for this part are very long and technical, making it difficult to sift through and find what is needed, making this part slightly less appealing. However, if it were to be implemented into the final design the chip would be sufficient in controlling all of the peripherals and interfacing the separate modules together. The cost of this chip is around $10 per chip, which is considerably higher than the PIC chips explained previously. When considering a part for the final design this chip's speed and available application notes will be remembered. There is however one more microcontroller that needs to be researched before making the final decision.

**MSP430:** This particular microcontroller is a very promising candidate for the final part selection and design. The MSP430 is a 16-bit microcontroller made by Texas Instruments and has some revolutionary features that may aid in the design of this project. The key feature that it boasts is the ultra-low power architecture that extends battery life for battery based applications. The power specifications that it enhances are listed below.

- $\mu$A RAM retention
- 0.7 $\mu$A  real time clock mode
- 165 $\mu$A/MIPS

The part also has some built in integration for peripherals that would be useful when implementing the different modules with the microcontroller. The full list of specifications for this part includes many things that will benefit the overall design of the project. The important aspects from the specifications are listed below.

- 16-bit ADC and DAC
- LCD driver built in
- Supply voltage supervisor
- DMA controller
- Real-Time Clock and built in watchdog timer

The cost of the part depends on the size of the chip and the features added but can range from $4 to $10. It also needs to be noted that this part has a lot of material online, such as application notes and tutorials which could help with programming the microcontroller and putting together the final design. One of the best features about going with this chip is the programming tool that is available. The programming and debugging of the microcontroller is a very important part in deciding which microcontroller to use.

**Development Tools:** The development tools are used to program the microcontroller with the programmer's code. It can also be used as a test and debug interface, to make sure the component works properly with the added code. All of the tools provide some way to connect the part to a computer so that code can be dumped or debugging can be worked through. Some of the bigger more extravagant tools have LCD screens to display debugging output, which could be useful when you need to see the data output in order to determine whether the device is working properly. The PIC microcontrollers can be interfaced with the Explorer 16 Development board. The board includes a number of features that would be crucial to developing the microcontroller to work in the project.

- Includes PIC24FJ128GA010 and the dsPIC33FJ256GP710 DSC Digital Signal Controller PIMs (100-pin version) or the PIC24FJ64GA004 PIM (44-pin version).
- Alpha-numeric 16 x 2 LCD display
- Interfaces to MPLAB ICD 2, MPLAB REAL ICE, USB, and RS-232
- Includes Microchip's TC1047A high accuracy, analog output temperature sensor
- Expansion connector to access full devices pin-out and bread board prototyping area
- Full documentation CD includes user's guide, schematics and PWB layout

**Figure 5.9.1** below shows the size and amount of tools and functionality available when using this as a tool. The main drawback to this using this as a development tool is the price of $130. There is a possibility that the board could be received as a sample for free, but that is yet to be determined via waiting on an email from the producer.

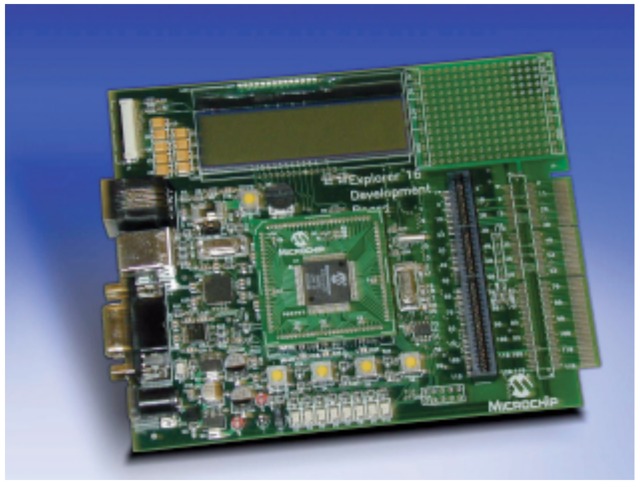



**Figure 5.9.1**
(Reprint with permission from Microchip)

This board will only work with PIC24 microcontrollers, so if the AT32UC3B chip is chosen as the microcontroller for this project, then a different evaluation board will need to be acquired. The Atmel piece needs to be interfaced using a specific board from the developer. The board for this particular microcontroller is the EVK1101, which is made only for the UC3B chips. This board allows the programmer to interface the microcontroller chip with a computer as well as a number of other peripherals via the evaluation board. The peripherals that are capable of being interfaced from the board are JTAG, Nexxus, USART, USB, TWI, and SPI. The board also includes a MMC and SD card reader. This tool is very important to developing the AT32UC3B, but the cost once again is a factor. This tool kit costs up to $80, making it a cheaper alternative then the PIC tool, but still high never the less. The development method for the MSP430 is a very interesting and promising tool for the scope of this project. The development tool eZ430-F2013 includes the software and hardware required all contained on a small USB accessible board. The whole unit can be seen in **Figure 5.9.2**, showing the versatility and compactness that the part has. Using this would enable the programmers to easily interface with the computer to dump code and debug. On top of compact and convenience issues, the tool offers many favorable features that would complement the design process of the microcontroller. A few of these features are listed below.

- eZ430-F2013 development tool including a USB debugging interface and detachable MSP430F2013 target board
- LED indicator
- 14 user accessible pins
- eZ430 debugging and programming interface supports development with all 2xx Spy Bi-Wire devices (MSP430F20xx, F21x2, F22xx)
- Removable USB stick enclosure
- Includes IAR Kickstart and Code Compose Essentials Core Edition which include an assembler, linker, source-level debugger and limited C-compiler

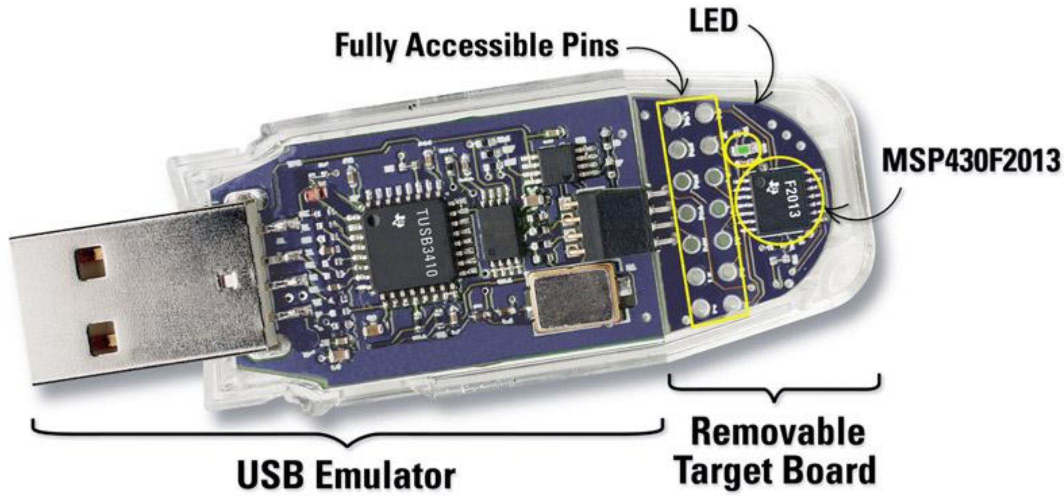



**Figure 5.9.2**
(Reprinted with permission from Texas Instruments)

This tool helps make the microcontroller from Texas Instruments more desirable. The eZ430-F2013 is small and easy to implement, and the cost is at a very impressive $20. The development tool is almost more impressive than the microcontroller that it is used to develop, but this will be kept in mind when the final decision for which microcontroller will be used in the project.

## 5.10. Launcher:

**Vibration**: Vibration, of the cell phone variety, is a very simple technique. Unlike some of the other techniques in this section, it only requires a few parts, and can be put together by a novice. You need three parts: a small dc motor, a gear, and a small weight. First, you connect the motor to the gear. Next, you place the weight on the gear, off center. The weight can be relatively small, but preferably over thirty grams. When the motor runs, it turns the gear. Because the weight on the gear is off center, it causes the vibrations when the gear is being turned.

**Figure 5.10.1** shows the weight and gear system of a Tickle-Me-Elmo toy. The vibration system of a Tickle-Me-Elmo works exactly like that of the vibration system in a phone. It has a gear (bottom) and an off-center weight (top). As the weight spins, the weight “jiggles” it causing the vibration.

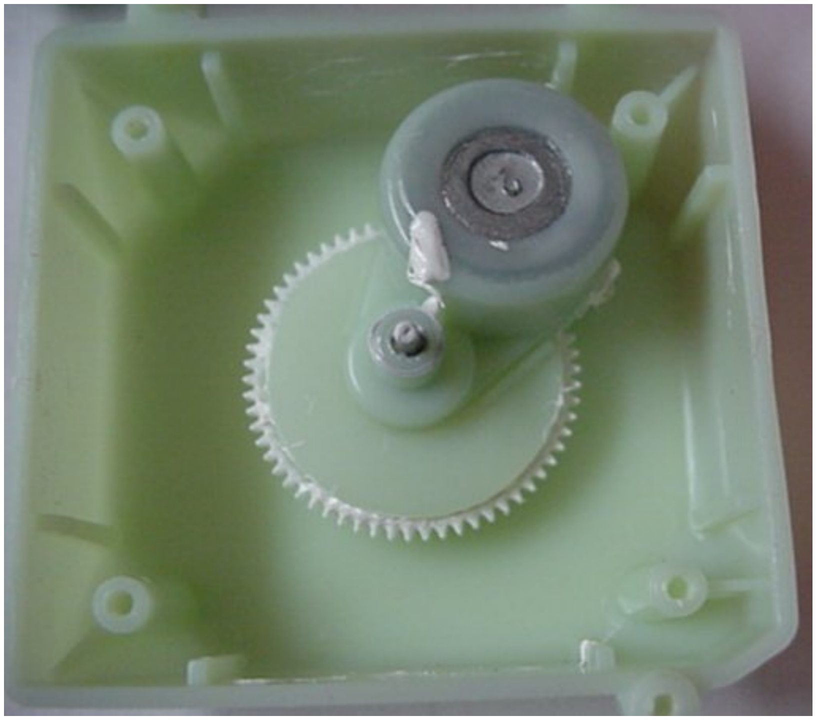


**Figure 5.10.1**
(Reprinted with permission from Howstuffworks.com)

This could work as a possible method for moving the speakers when the alarm is going off. There are some issues however. One issue would be trying to get the right amount of movement, preferably enough to move the speakers off a table. That can be manipulated with the size of the weight and the motor speed. The motor speed alone could go even surpass 10000 RPMs. Another issue would be dealing with the power needs of having a motor in each speaker. The power source of the speaker would have to be great enough to power the motor without losing the ability to power the speaker output and the wireless receiver in each speaker.

Another issue is noise. While it does seem strange to worry about noise when you are talking about a speaker, but it can be a serious issue. If the noise from the vibration is too loud, the speaker output will have to be increased, which in turns requires more power. And if the sound of the speakers is increased to compensate for the sound of the vibration, is it too loud for safe usage? These are some of the issues that using vibration causes.

**Fan System**: Another possibility for the movement of the speakers is a fan system in the main section of the alarm clock. The way a fan system would work is pretty much common sense. A “fan” blows air. In this case, there would be too fans in the base of the alarm clock that blow air towards the speakers. The speakers would have to unhook from the base when the alarm goes off, perhaps by some sort of electronic latch system and the fans would propel them across the table/nightstand/etc.

This was an early idea considered for the system, but it was quickly shot down. There are two many dangers and flaws with using a fan system to move the speakers. First would be the power for the fans needed to move the speakers. Either the speaker would have to be very light weight or the fans would need to very high powered. The speakers can only be so light. If we make it too light, it will not offer any protection and if it is not light enough, there is a chance that the fans cannot move them.

And the fan would also have to fit within the main section of the alarm clock, so it would only be able to be within a couple of inches in diameter. This, of course, decreases the amount of “air power” it is able to output. Logically, it does not make any sense for a fan that small to be able to push speakers of any size very far. The only to possibly account for that is just to increases the speed of the fan. But how fast it too fast? We do not necessarily want something moving at 20,000 RPM, assuming the system would even be able to handle something moving that fast.

The danger, as melodramatic as that sounds, is very much real. Having two spinning blades is a big risk when dealing with someone who has just woken up. The blades would have to be dulled, and even then, if a hand or a finger touched them it would be very painful. True, they would be awake, but maiming the user is not part of this alarm clock’s design. It would also be a hazard if the owner of the alarm clock had a pet that could get to the spinning blades. One method of solving this problem would be to coat the blades in a protective covering, but that would add to their weight, reducing the speeds they could spin and in turn, reducing their air output. Another workaround would be to put some sort of mesh like covering over the opening, between the fan and the speaker. This would protect the user from the fan. However, this would complicate the connection between the speaker and the base of the alarm, as it would have to be configured around/through the mesh.

Dyson is currently selling a fan that would solve at least one of the problems with a fan system. Their fans have no blades. So the dangers of physical damage to the user are gone. This technology would work well for us except for two caveats: it is new technology so the price is quite steep, at $299.99 per fan unit (and we would need two) and the smallest system the sell is ten inches, which is far too large to fit inside the base of the alarm clock.

**Pressurized Gas**: Another method to launch the speakers from the base is to use a pressured gas system. This would work similarly to way a paintball gun fires a paintball. A canister of gas is set up inside the main base of the alarm clock, and the alarm clock is “cocked” a minute before the alarm is set to go off. When the alarm goes off, the gas is released and the pressure forces the speakers away from the main section of the alarm clock. This is actually very

similar to the water system in a way, but without the required clean-up every time the alarm goes off.

A $CO_2$ canister used to power a paintball gun **Figure 5.20.2**


**Figure 5.10.2**
(Reprinted with permission from Paintball Equipment Wikipedia)

Using a canister of pressured gas to launch the speakers would give the explosive effect that something called an Explosive Alarm Clock is looking for, so that is a plus for this idea. However, finding a canister that fits within the alarm clock will be difficult as most of the canisters are the same size, and made to fit on a paintball gun. Let us say, for the sake of argument, that a canister of the proper size exists. As the picture above shows, these canisters are not supposed to be used in temperatures above 130$^o$ F. How could it be guaranteed that the temperature would not get too hot for the canister? How could it be guaranteed that the user of the alarm clock was not in some sort of danger? Because of the size of any canister, it would be very close to the electronics inside the alarm clock, thereby increasing the temperature.

Getting a system inside the alarm clock to control the release of the gas would not be that hard. A paintball gun uses a rod and a valve covering, when the rod is pressed back (as when the trigger is pulled) it pushes against the valve tube. This pressure opens the “lips” of the valve tube, allowing the gas to escape. Implementing a similar system inn the alarm clock could be done with just a valve controlled by the microcontroller of the alarm clock. The alarm goes off, the valve is opened by 3 seconds, and then the valve is closed.

**Water**: Another method for moving the speakers is using water. The idea is to use a “water gun” like effect to push the speakers away from the main base of the alarm clock. Pressure builds up in the main section and when it is released, the concentrated blasts are enough to move the speakers around the room. This would work in a water gun like fashion, using the “super soaker” mechanisms as a blueprint. We would have a main reservoir of water that is refilled by the user every night when setting the alarm. The reservoir is connected to two pipes that

point to each speaker. The pipes are clamped off at the end, to keep the water from dripping and/or shooting out before the appropriate time.

As the time gets nearer for the alarm to go off, the system begins to compress the reservoir container. A compression system would obviously have to be built to compress the water reservoir. This builds up pressure in the container in which the water is now trying to escape. It cannot go out the endpoints because those have been blocked off. When the alarm goes off, the clamps are released and the water pressure does it's best to equalize with the pressure of the outside world. The water is shot out of the main part of the alarm clock and it pushes the speakers away.

Again, this has some downsides. The most obvious is water. It will be everywhere. There is no way the alarm clock would be able to keep the water in a specific location. It could be aimed, the same way a water gun would be, but it would still drip from the starting location to the target. Another worry would be keeping the water from messing with the circuitry of the alarm clock. It would also be a hassle for the user to have to refill the water every night when setting the alarm and to have to clean the water up every morning after the alarm goes off. And there would, of course, be the danger of having a puddle of water around someone who is not full awake. There would be some danger of slipping and falling.

A picture of the Super Soaker's "bladder", part of the Constant Pressure System **Figure 5.10.3**

**Figure 5.10.3**
(Reprinted with permission from howstuffworks.com)

Another downside is the compression system. The alarm clock body would have to be big enough to hold the water reservoir at its fullest point and hold the

system that would squeeze the reservoir (the compression system). The moving parts would take up a bit of room, and may push the alarm clock's size past a comfortable range. No one would want to buy an alarm clock that was ten inches tall just so it could douse their room in water everyday at six AM. It makes no sense for someone to want that, so it makes no sense for someone to make that.

**Spring**: The final method choice for propelling the speakers away from the main section of the alarm clock is via a spring. The spring would be compressed whenever the speakers are attached to the base of the alarm clock. The alarm clock innards would be in the center region of the base, leaving some room for the spring to go into the clock. When the alarm goes off, the speakers will be unlatched from the base, and then springs will be released. In their attempts to get back to their uncompressed lengths, the springs will fly towards the speakers, using all their force to propel the speakers outward.

Obviously, a spring on its own will not get the speakers very far. But if it is attached to a square plate of some sort, when the spring is released, the plate is pushed against the speakers and it gives it a fuller, even push. The plate idea is reminiscent of the board game "Perfection" from Milton Bradley. In that game, when the timer runs out the board is sprung up in the air. So like the situation just described, it would be a spring connected to a large, plate like material. The timer in the alarm clock's case is, of course, the alarm going off.

Another possibility in using a spring as a propellant is attaching a bearing to the end of the spring. When the spring is released from compression, the bearing will hit and press against the speakers, propelling them. That way it keeps a square plate from being needed. However, since the force from the spring would be concentrated, the speakers would have to be impact resistant enough to hold up against the constant daily pressure in the same spot from the bearing. Just like no one would want a speaker that breaks when it hits the floor, no one wants a speaker that beaks when it gets pushed away from the main base of the alarm.

But again, like all the other possibilities, there are some kinks that need to be worked out. First is the power the spring puts out. It needs to be powerful enough to push the speakers, preferably push them a fair distance away from the main base of the alarm. The spring needs to be long enough to gain this sort of power. But it's not like the spring length can just be increased without any limitations. It can only be as long as the base of the alarm clock is long. Not only that, but its length is also determined by what is "in the way". For example, if the alarm clock base is 6 inches long, the spring cannot necessarily be 6 inches long. If the circuitry is part of the alarm, which it very well should be, it would be taking up some of those 6 inches. The spring would either have to be placed that it goes above or below the innards of the alarm clock, or be shortened so that it does not reach them.

Another issue is how many springs to use. Since there will be two speakers, two springs might have to be used. Using two springs, however, multiplies the danger of hitting some internal part of the alarm clock with the spring. Or there could be a single rod, with two spring endpoints. That way the rod is stationary; it's a constant aspect. The two springs on the end are the points that get compressed, and they follow the same pattern of compression as talked about earlier. It should work with either method (the plate or the bearing). Preferably, the area that is solid and non-compressible would be the part that is around the innards of the alarm clock. That way the design would not have to worry about changing dimensions of objects when planning what goes where.

## 5.11. Wireless Technology for Speakers

For the exploding alarm clock to have any success at all the speakers have to be able to be removed from the base without any connection to the base. For this to be possible the speakers need to be wireless. To transmit audio wirelessly some some sort of wireless transmitter and receiver are needed. Two common ways are radio frequency and bluetooth.

**WT32 Bluetooth Audio Module:** The WT32 bluetooth module has many features that are ideal for this project. Since it is designed specifically for audio it makes it a great component for us to use. This part can be used for both transmitting and receiving so with three of them we can create out whole wireless speaker system. By setting one in source mode we can transmit a stereo audio signal and then using one in sync mode at each speaker we can receive left and right audio to the appropriate speaker.

The pre-installed firmware on this device always for easy configuring the device to do what we need. It is easy to use and plenty of guidance is available on the manufactures website. Since it uses Advanced Audio Distribution Profile it will allow the modules in sync mode to sync with any device that also uses this audio profile for bluetooth. This will allow for the user to use the speakers without the base station as a set of portable wireless speakers.

**Zoom iHiFi 4370 Transmitter/Receiver:** Is another option for wirelessly transmitting the audio. This device uses the audio jack of a music player and transmits the audio. This is probably not a good device for us to use because it would be a separate part and would be hard to actually build into our clock. In most cases the audio jack is nowhere near the usb port and we would need both ports for the system to function. Since we need data from the usb port to be able to display information on the scree we need to be able to easily access all the information through one port. Therefore usb is the best access.

**nRF24Z1 Transceiver for Audio Streaming:** The nRF24Z1 is a 36 pin wireless audio package. This device is capable of producing up to a 4Mbit/s RF link. For

our implementation this is plenty of bandwidth. Since we are only streaming simple mp3 files. The downside to this device is that it is meant for transmitting data not receiving it so we would have to find a separate receiver to use at the speakers. Although it receivers are abundant it makes implementation harder since we will need to learn how to use to separate device as apposed to learning to use one device and it handling everything within the system it is used in.

## 5.12. Speakers:

Choosing the correct speaker is a key step in this project. Not only does it affect the sound quality of the speaker it affects how the speaker is projected. Size and weight are extremely important. The larger the speaker the more powerful the projection method will need to be. The weight of the speaker affects how strong the method of projection should be. So picking a speaker that is lightweight at the same time as being efficient is key to success.

**iHome iHM77 “Capsule Speakers”:** One option is the iHome iHM77 Capsule speakers. They include amplified speakers and a built in rechargeable battery. This will allow for simplified circuitry in the speaker section of the clock. The capsule speakers have a mini-usb out that allows for charging and audio output. Through this the designers can interface the speakers to both power to recharge them from the base and whatever method we use to wireless transmit audio to them.

The speakers are approximately 1.42” x 2.09” x 2.09” and way about 1.92 oz according to the product description on the apple website. There small size and light weight make them a great option for use. They also will fit nicely into whatever casing we use for the whole system. This way we can fit the speakers, the wireless module, and any power we need into one sleek case. Size and simple mini usb interface are shown in **Figure 5.12.1** below.

**Figure 5.12.1**
(Reprinted with permission from notebooks.com)

The cost of these speakers is also relatively low for whats include. For fifty dollars we get everything within the speaker system including amplifiers for each speaker, a rechargeable battery and the mini usb port. In order to build it ourselves the designers would have to buy everything need for the circuity in the speakers, the speaker itself and the amplifier.

**BXR1220:** The BXR1220 portable speakers by Altec are another cheaper option for speakers. They are powered by usb and they use an auxiliary jack for audio. Since they don't have individual auxiliary ports on each speaker and are connected to each other by a wire, changes would have to be made to the speakers to make them two separate parts. This would make it harder to make them into to separate wireless speakers.

These speakers are also slightly larger than the then the previous option but not by enough for it to have a huge affect on the design. Although the lack the flexibility of the first option they are sill a viable option for use in the design for the speaker section. Since it is cheaper it might be worthwhile because it will make it easier to stay within our budget. They changes that need to be made are minimal and is mainly just breaking them up into two separate speakers that do not depend on each other.

## 5.13. Battery:

Since the speakers are going to be able to be split from the main base, they need to have some sort of battery power. The point of shooting out the speakers is to force the user to get up to stop the sound, not just to teach them to unplug the

main base to stop the sound. Because of that, the speakers need to be able to last a lengthy amount of time unplugged from the main base of the alarm clock without sacrificing the speaker's capabilities to play music/the alarm sound. But the batteries also have to be able to fit within the speaker's housing.

There are two main options of a battery pack system to go with. One is the disposable type. The user can continue to supply batteries of their own choosing whenever the batteries in the speaker run down. The speakers will be designed to run on whatever battery type is chosen to be powerful enough. The second is that the alarm clock will come with a rechargeable battery of some sort (either something like rechargeable AAs or cell phone style Lithium-ion battery). It was decided early on that this project wanted to include the ability to charge batteries placed in the speaker. The alarm clock idea needs to be novel and useful to the user, not a never ending source of cost. So the research discussion will focus on the second part. There are five main chemical types of batteries. They are Nickel-cadmium, Nickel-metal-hydride, Lead-acid, Lithium-ion and Alkaline.

**Nickel-Cadmium**: Nickel-cadmium is the oldest of these technologies and has a moderately low energy density. Nickel-cadmium is useful when the designer wants longevity, high discharge rate and a good temperature range. Nickel-cadmium is used in devices like power tools, and two-way radios. It does, unfortunately, contain toxic materials so disposal of the Nickel-cadmium batteries after they wear out is an issue. Nickel-cadmium batteries prefer faster pulse charging, as opposed to slower DC charging.

Isidor Buchmann, founder of Cadex Electronics, even says that "Nickel-cadmium is the only battery type that performs well under rigorous load condition". Nickel-cadmium does not like being used only a little bit and then sitting in a charger for a while. This may hurt its ability to be used in the alarm clock, unless it can somehow be guaranteed that the user of the alarm will be constantly detaching the speakers and using the alarm clock as a media player. If it does sit like that, eventually the cell plates on the battery crystallize (which is called memory in battery lingo) and the battery loses performance. But Nickel-cadmium is cheap, and so it becomes a trade-off between what it can do and how much it costs. The following table shows the advantages and limitations of the nickel-cadmium battery.

Data taken from Batteryuniversity.com

Advantages of Nickel-cadmium batteries:

- Fast and simple charge, even after prolonged storage.
- High number of charge/discharge cycles - if properly maintained, nickel-cadmium provides over 1000 charge/discharge cycles.
- Good load performance - nickel-cadmium allows recharging at low temperatures.

- Long shelf life - five-year storage is possible. Some priming prior to use will be required.
- Simple storage and transportation - most airfreight companies accept nickel-cadmium without special conditions.
- Good low temperature performance.
- Forgiving if abused - nickel-cadmium is one of the most rugged rechargeable batteries.
- Economically priced - nickel-cadmium is lowest in terms of cost per cycle.
- Available in a wide range of sizes and performance options - most nickel-cadmium cells are cylindrical.

Limitations of Nickel-cadmium batteries:

- Relatively low energy density.
- Memory effect - nickel-cadmium must periodically be exercised (discharge/charge) to prevent memory.
- Environmentally unfriendly - nickel-cadmium contains toxic metals. Some countries restrict its use.
- Relatively high self-discharge - needs recharging after storage

**Nickel-metal-hydride**: Another type, Nickel-metal-hydride (NiMH), has a higher energy density than Nickel-cadmium, with up to 40% higher than nickel-cadmium but its cycle life (which is the total number of charge and discharge cycles the cell can sustain before it no longer works as designed) is reduced. Nickel-metal-hydride does not contain any toxic materials, so disposal is not a problem like it is with Nickel-cadmium. In fact, the lack of toxic materials is part of what has made nickel-metal-hydride batteries as popular as they are. Nickel-metal-hydride batteries are used in cell phones and some laptops. However, nickel-metal-hydride batteries are not at good as nickel-cadmium under heavy loads or higher temperatures. The following table shows the advantages and limitations of the nickel-metal-hydride battery.

Data taken from Batteryuniversity.com

Advantages of Nickel-metal-hydride batteries:

- 30-40% higher capacity than standard nickel-cadmium. Nickel-metal-hydride has potential for yet higher energy densities.
- Less prone to memory than nickel-cadmium - fewer exercise cycles are required.
- Simple storage and transportation - transport is not subject to regulatory control.
- Environmentally friendly - contains only mild toxins; profitable for recycling.

Limitations of Nickel-metal-hydride batteries:

- Limited service life - the performance starts to deteriorate after 200-300 cycles if repeatedly deeply cycled.

- Relatively short storage of three years. Cool temperature and a partial charge slows aging.
- Limited discharge current - although nickel-metal-hydride is capable of delivering high discharge currents, heavy load reduces the battery's cycle life.
- More complex charge algorithm needed - nickel-metal-hydride generates more heat during charge and requires slightly longer charge times than nickel-cadmium. Trickle charge settings are critical because the battery cannot absorb overcharge.
- High self-discharge - typically 50% higher than nickel-cadmium.
- Performance degrades if stored at elevated temperatures - nickel-metal-hydride should be stored in a cool place at 40% state-of-charge.
- High maintenance - nickel-metal hydride requires regular full discharge to prevent crystalline formation. nickel-cadmium should be exercised once a month, nickel-metal-hydride once in every 3 months.

**Lead-acid**: Lead-acid is the third main type of battery. Lead-acid batteries are very weighty and are "most economical for larger power applications where weight is of little concern…hospital equipment, wheelchairs, emergency lighting and UPS systems". They have a slow typical charge time (up to 16 hours) but the battery periodically has to be fully charged. The need to be fully charged every now and then should not cause a problem, as the user would keep the speakers (and therefore the batteries) attached to the base while they sleep. This would give around 8 hours, not including any time in the day that they were not using the speakers. They are cheap and get the job done, at the expense of weight and portability.

Like Nickel-cadmium, Lead-acid batteries contain toxic materials and therefore disposal is a problem. In this case, the toxicity is due to high contents of lead (as is obvious from the name) and the possibility of leaking lead acid. Lead-acid batteries have a very low energy density and that makes their usage in portable devices limited. The probability of lead-acid batteries coming out on top in the decision on what battery type to use is slim, as they are huge. A lead-acid battery is the battery that is sitting in almost every car at this moment. They are big, and they are heavy and compared to a similarly weighted battery of any other type, they have a low energy density.

The "sealed lead acid" and the "valve-regulated-lead-acid" were developments made within the past few decades that keep "the battery from reaching its gas-generating potential during charge" which keeps the leakage down to a minimum. This would keep part of the danger of using a lead-acid battery in the speakers down to a minimum. And in even newer technology, like the Absorbed Glass Mat Batteries, have very little to no leakage, much more efficient than even the VRLA or SLA batteries. The AGM batteries are also much more durable, able to handle a lot of shock and vibration, which is something that being in the speakers will

cause them to experience a lot of. The following table shows the advantages and limitations of the lead-acid battery.

Data taken from batteryuniversity.com

Advantages of lead-acid batteries:

- Inexpensive and simple to manufacture.
- Mature, reliable and well-understood technology - when used correctly, lead-acid is durable and provides dependable service.
- The self-discharge is among the lowest of rechargeable battery systems.
- Capable of high discharge rates.

Limitations of lead-acid batteries:

- Low energy density - poor weight-to-energy ratio limits use to stationary and wheeled applications.
- Cannot be stored in a discharged condition - the cell voltage should never drop below 2.10V.
- Allows only a limited number of full discharge cycles - well suited for standby applications that require only occasional deep discharges.
- lead content and electrolyte make the battery environmentally unfriendly.
- Transportation restrictions on flooded lead acid - there are environmental concerns regarding spillage.
- Thermal runaway can occur if improperly charged.

**Lithium-ion**: The final type of battery is the Lithium-ion battery type. It is the most recently developed of the batteries types. There are three different types of Lithium-ion batteries: Lithium-ion-cobalt, Lithium-ion-manganese and Lithium-ion-phosphate. They offer high energy density with a low relative weight. Lithium-ion batteries have an energy density double that of nickel-cadmium. The cycle life is also equal to or greater than that of Nickel-metal-hydride. And there are also no worries about memory (crystallization) in Lithium-ion batteries. However, because of the instability of the Lithium-ion cells, they would need to have a protection circuit to keep them within the appropriate range of values in load, temperature and voltage.

Data taken from batteryuniversity.com

Advantages of Lithium-ion batteries:

- High energy density - potential for yet higher capacities.
- Does not need prolonged priming when new. One regular charge is all that's needed.
- Relatively low self-discharge - self-discharge is less than half that of nickel-based batteries.
- Low Maintenance - no periodic discharge is needed; there is no memory.
- Specialty cells can provide very high current to applications such as power tools.

Limitations of Lithium-ion batteries:

- Requires protection circuit to maintain voltage and current within safe limits.
- Subject to aging, even if not in use - storage in a cool place at 40% charge reduces the aging effect.
- Transportation restrictions - shipment of larger quantities may be subject to regulatory control. This restriction does not apply to personal carry-on batteries. (See last section)
- Expensive to manufacture - about 40 percent higher in cost than nickel-cadmium.
- Not fully mature - metals and chemicals are changing on a continuing basis.

There are also Lithium-ion-polymer batteries. It uses a dry solid polymer electrolyte with some gelled electrolyte added to counter the low conductivity of the polymer. Their energy density is slightly lower than what a normal Lithium-ion battery can put out, but they can be shaped to a wafer-thin form. They cost a bit more to manufacture than standard Lithium-ion batteries, which will in turn raise the price of purchasing these batteries.

Data taken from batteryuniversity.com

Advantages of Lithium-ion-polymers:

- Very low profile - batteries resembling the profile of a credit card are feasible.
- Flexible form factor - manufacturers are not bound by standard cell formats. With high volume, any reasonable size can be produced economically.
- Lightweight - gelled electrolytes enable simplified packaging by eliminating the metal shell.
- Improved safety - more resistant to overcharge; less chance for electrolyte leakage.

Limitations of Lithium-ion-polymers:

- Lower energy density and decreased cycle count compared to lithium-ion.
- Expensive to manufacture.
- No standard sizes. Most cells are produced for high volume consumer markets.
- Higher cost-to-energy ratio than lithium-ion

Using Lithium-ion batteries of any sort comes with some considerable worries/ danger involved. In the past few years, there have been plenty of horror stories about Lithium-ion batteries in computers or in portable media devices have exploded or caught fire. There were incidents where a Lithium-ion battery in a cell phone released gases that burned a man’s face, computer and cell phones

that exploded and caught fire to people's legs, etc. Obviously, putting the user in such a dangerous situation is something definitely has to be avoided. A small issue in the manufacturing process can spell big danger for the user of the battery, such as small metal particles coming in contact with other parts of the battery.

Lithium-ion batteries come with a protection cell to keep the above image from happening to anyone. It limits the current path from the cell if the voltage gets too high, or if the skin temperature of the device rises to an unsafe level.  It releases gas (in a controlled manner) if the pressure gets too high. There is also a solid state switch in case the charge voltage in any cell of the Lithium-ion battery reaches 4.3V. And if the internal cell pressure rises, there is a circuit interrupt device open the electrical path if an excessively high charge voltage is the cause. So the Lithium-ion batteries do come with protection against cell issues, but how will those protections hold up again the constant slamming against the floor by the speakers? In order to safely use a Lithium-ion battery, the safeguards protecting the safeguards have to be top-notch. The batteries will have to be made shockproof, maybe being held in place by some sort of secure frame in order to take no damage from the fall.

**Alkaline**: The final category of batteries is the Alkaline battery. It has a low cost compared to many of the other batteries and was created for use in consumer goods. Rechargeable Alkalines have been used in many home entertainment devices, flashlights and other general consumer products. They do well being recharged when at above 50% which is acceptable for the alarm clock, because most of the drain of the batteries will come from the daily alarm clock use and less from using the alarm clock as a stereo system. It makes sense that the average person will use their alarm clock five days a week (during an average work week), but may be using the stereo feature once or twice during that same week.

A rechargeable Alkaline loses a bit of its charge every time it is recharged (the first time being the most drastic change, and every following time being minimal). Rechargeable Alkaline batteries usually settle around 60% of the manufacturer's rated capacity. And as stated before, the more discharge you have, the less the next charge will be. So as long as the user is not constantly completely draining the battery, it should last. The load capability of the rechargeable Alkaline system is only 400mA. Most other battery types provide a lower load current than that, when it has been coupled with a lower internal resistance, provides for higher quality power output. Alkaline is also the lowest price system, but is more costly in the long run if the user is fully discharging the battery each time.

Recharging it before it is completely drained helps save money and cycles. As Isidor Buchmann puts it, "Cost savings are realized if the batteries are never fully discharged but have a change to be recharged often". If the batteries are continuously fully discharged, it would be more cost efficient just to have the user

of the alarm clock buy new disposable batteries every time they die. Also, rechargeable Alkaline batteries do not use any toxic metals, and therefore disposal of them (when they do finally die) is not an issue.

Data taken from batteryuniversity.com

Advantages of the Alkaline battery:

- Inexpensive - can be used as a direct replacement for non-rechargeable (primary) cells.
- More economical than non-rechargeable - allows several recharges.
- Low self-discharge - can be stored as a standby battery for up to 10 years.
- Environmentally friendly - no toxic metals used, fewer batteries are discarded.
- Maintenance free - no need for cycling; no memory.

Limitations of the Alkaline battery:

- Limited current handling - suited for light-duty applications like portable home entertainment, flashlights.
- Limited cycle life - for best results, recharge before the battery gets too low.

## 5.14. Battery Charger:

As stated in the battery section, the alarm clock will eventually have the capability to charge the batteries that power the speakers. Now as obvious as it sounds, the type of batteries chosen will determine the type of charger. This is important as the chargers for the differing batteries types work differently. Obviously what charges a pair of rechargeable AAs, AAs, and etcetera is not going to work for something that charges your typical cell phone or laptop computer battery. Battery chargers made to charge any specific type of battery will have a few things in common with one another, however.

First, the charger will have to start working without any input from the user of the alarm clock. The charging system needs to work regardless if the user clicks the right switch or pushes the right button combination. Second, the charger needs to be able to tell when the battery is fully charged, and stop it from getting any more power from the charging system. A system that does this solves two problems: 1) stops the user from having to continuously check the charging system to see if it is finished 2) stops the system from overcharging the batteries (and possibly causing damage to the battery or the alarm clock system).

Another thing the charger system needs to do is only charge the battery once it reaches a certain point. If all the user does it unhook the battery powered speakers from the base for 10 seconds, it should not need to call the charging system the next time they are plugged in. A possible solution for this is to set a power limit for the charger system. In other words, set it up so that the charger

only charges once the battery passes a certain threshold of lost power. For instance, if the threshold was seventy percent, the charger would not charge if the battery was first plugged in at seventy-four percent, but would start charging a battery if it was plugged in at sixty-nine percent. An issue with this is, of course, how does the system know if the seventy-six percent the battery is currently at is a starting point or is a middle point in a charging session that started at fifty percent. Those are the details about what the charger needs to do regardless of what format/style/charge of batteries are decided upon for the alarm clock speakers.

**Nickel based chargers**: When it comes to charging a nickel-based battery there are three types of chargers. There is the slow charger, the quick charger, and the fast charger. Their respective charging speeds are ordered as they were written, from slowest to speediest. These apply to both Nickel-cadmium and Nickel-metal-hydride rechargeable batteries.

Data taken from Battery University

- ***Slow Charger*** - Also known as 'overnight charger', the slow charger applies a fixed charge of about 0.1C* (one-tenth of the rated capacity) for as long as the battery is connected. Charge time is 14-16 hours. Slow chargers are found in cord-less phones, portable CD players and other consumer goods.
- ***Quick Charger*** - Also knows as rapid charger, this charger serves the middle range, both in terms of charging time and price. Charging time is 3-6 hours. The charger switches the battery to trickle charge when ready. Quick-chargers are used for cell phones, laptops and camcorders.
- ***Fast Charger*** - Designed for nickel-based battery, the fast charger fills a pack in about one hour. Fast charging is preferred because of reduced crystalline formation on the cells (memory). Accurate full-charge detection is important. When full, the charger switches to topping and then trickle charge. A fast charger battery can get a Nickel-cadmium battery charged up to seventy percent in just a few minutes. Fast chargers are used for industrial devices such as two-way radios, medical devices and power tools.

Nickel based batteries with a higher than normal capacity have a high resistance and due to that, they tend to heat up at a higher rate than standard capacity batteries when charged in a fast charge system. Also, if a fast charger is chosen, it needs to have the ability to lower the charge being sent to the battery after the first 70% is charged. After the first 70% the battery gradually loses the ability to accept charge, and so the charger must change to a trickle charge to complete the charging process. A nickel based charger can only handle being used in temperatures ranging from 45$^{o}$F to 113$^{o}$F, with the more extreme ends causing less capability in the ability to charge. Those temperatures are hard to beat, but

that some precautions would have to be taken for winter in the northern areas of the world.

If a Nickel-metal-hydride battery is chosen, a slow charger is a bad idea. Close to impossible to be more precise. At the low currents of a slow charger, a charger won't be able to properly read the full charge state and therefore relies on a timer. A timer is a bad choice when it comes to batteries, as the timer does not know how much charge is in the battery or if the battery has lost capacity and can hold less than it initially could. All it knows is that it has to charge for a set amount of time no matter what. This will very easily lead to overcharging, something that should be avoided. The Nickel-metal-hydride charger would also need to check for the full charge voltage by more than just a charge reader. Voltage while charging Nickel-metal-hydride tends to fluctuate, so the charger has to check for full charge using a combination of voltage, rate-of-temperature-increase, temperature, a timer, and NDV (negative delta V- a drop in battery voltage due to overage).

**Lead-acid chargers**: Lead-acid battery chargers are similar to Lithium-ion chargers in that voltage limiting is used instead of current limiting, like in Nickel based chargers. The charge time is longer than that of Nickel based battery chargers and Lithium-ion battery chargers, at about fourteen hours for a full charge. If the charger is multi-stage, it must apply these three stages: 1) a constant current of about 1A is applied to the battery. When the battery reaches seventy percent (about 5 hours), 2) the charge current "is gradually reduced as the cell is being saturated". This takes another 5 hours and ends when the battery reaches full charge. Full charge is determined when the "voltage has reached threshold and the current has dropped to 3% of the rated current or has leveled off." Then 3) the topping charge is applied, which is just charge to compensate for the battery's self-discharge.

Graph of the voltage/current of a Lead-acid battery/applied to a battery during the charging process. **Figure 5.14.1**

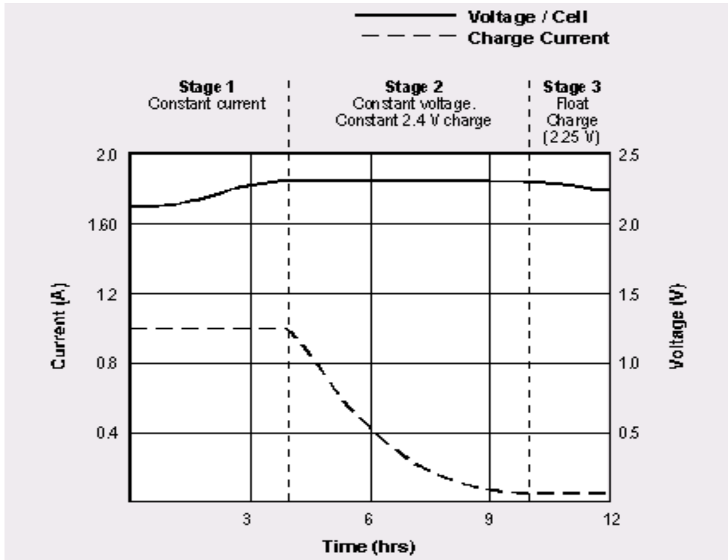



**Figure 5.14.1**

(Reprinted with permission from batteryuniversity.com)

The voltage limit can be chosen by the designer of the charger. If the voltage limit is between 2.3V and 2.35V per cell, the battery has a longer maximum service life, battery is cool during charge, and the temperature of the room can be greater than 30$^{o}$C, but the charge time is slower, capacity readings are inconsistent and it needs a topping charge for safe use. If the voltage limit is between 2.4V and 2.45V per cell, the charge time is faster, the readings are consistent and less chance of danger without a topping charge, but the room temperature must be lower and the battery may not reach the voltage limit. It seems like the higher charge would be easier for the user, as most houses are not going to be at the 30$^{o}$C temperature range, and that's the only real worry when it comes to the higher voltage limit. A lead-acid charger can handle temperatures between 45$^{o}$F and 122$^{o}$F.

**Lithium-ion chargers**: As talked about in the battery section, Lithium-ion batteries are dangerous. As such, there aren't many ways to charge them (like there are for the Nickel based batteries). For your average Lithium-ion battery charge there are three stages. First stage is the application of the maximum charge current. This is done until the cell voltage limit is attained. This point is usually reached in a little over an hour. Then, during stage 2, the charge current is slowly decreased as the voltage rises to meet the full charge point. At stage 3, where the full charge point is met, the charging current is shut off and every now and then a topping charge is applied.

Graph of the voltage/current of a Lithium-ion battery/applied to a battery during the charging process. **Figure 5.14.2**

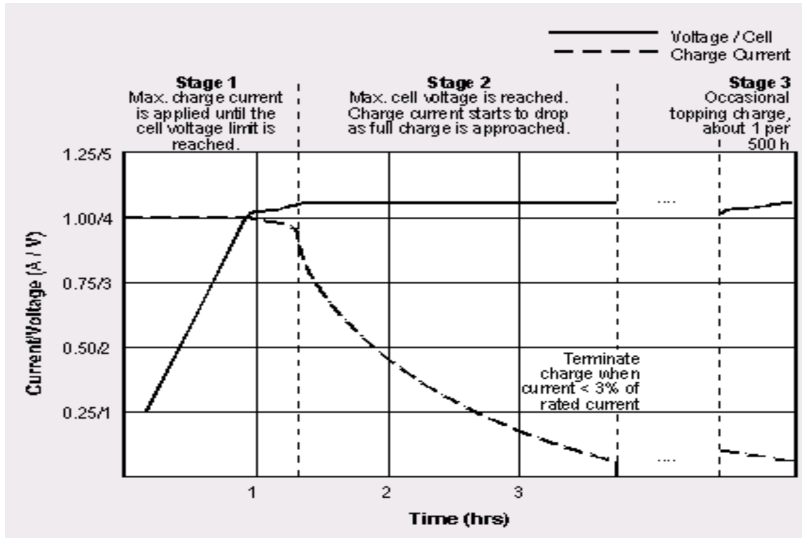



**Figure 5.14.2**
(Reprinted with permission from batteryuniversity.com)

The total charge time is about 3 hours with a charge current less than 1C. If the charge current is increased (say to something greater than 1C) the maximum cell voltage is reached quicker, but the topping charge than takes longer. There are some Lithium-ion chargers out there that say they can fast charge a Lithium-ion battery. What they do is skip stage 2 and go straight to topping charge, so the first hour of the charge just gets it to the seventy percent that is reached after stage 1 of a normal charger. But because of the lack of stage 2, the stage 3 portion of the charging (topping process) takes a lot longer.

The Lithium-ion charger chosen would have to be very accurate in its ability to tell when the full charge is reached. Lithium-ion batteries get very unstable when overcharged. Their unstable leads to dangerous scenarios for the user of the alarm clock, and should be avoided at all costs. But the good thing about Lithium-ion batteries is that the monitoring process is simpler than that of Nickel Cadmium. The charger has only 2 things to monitor: the current voltage (and cutting the current off when the voltage hits a certain point) and "the current saturations at full current." A Lithium-ion charger can only be used at temperatures between 32°F and 113°F. Anything beyond those extremes exposes the users to extreme danger from the battery. Fortunately, those temperatures are hard to come by in a house, but that does make it hard for those in the northern parts of the world during winter.

## 5.15. Battery Indicator:

Since the speakers will have their own portable power supplies, they need some way of informing the user when the batteries need recharging. There are two ways to go about this: 1) a system can be implemented that tells the user what battery power is remaining at all times or 2) a system that only notifies when

power is low. System one can be implemented in a few different ways: there can be the specific percentage of battery power left, or the general idea of battery power left.

The former requires a system that can read tell details about the power remaining in the battery at regular intervals. The second requires a general knowledge of where the power is at. Using system two, the charge checking system can be simplified to only check momentarily and notify only when the battery changes from a good battery level to a low battery level. Both of these do not have to be constantly checking; there can be a time limit between checks so as to limit power drain. That leads to the biggest worry when it comes to a battery indicator: power drain. A battery indicator that wears down the battery its indicating for is not what is wanted. There needs to be a fair tradeoff between how often the power levels are checked, and how much power it drains. In other words, the power left in the battery needs to be checked just enough that the user is not unaware of a low battery and no more than that. This is important because "draining excessive battery current in the circuit…can lead to permanent battery damage."

The battery indicator would also have to be close to somewhat close to accurate. Whatever method is chosen for displaying the battery, the user needs to know within a reasonable amount of time, when the battery needs to be charged again. If the battery indicator is indicating a good battery level, the user may opt to keep it from charging in order to listen to music. But if it dies on them within a few minutes because the system is not accurate enough, they are going to be highly disappointed in the alarm clock. What good is a battery indicator that does not work?

A battery indicator that exemplifies simplicity is the one on the Xbox 360 controllers. It is just a LED light but when the battery low it flashes every few minutes to alert the user. It does not take up a lot of battery power as it is not flashing continuously, and it only check every few minutes (which is why it only flashes every few minutes). This is something that the speaker's battery indicator will strive to be. Simplicity and usefulness combined.

# 6. Design

## 6.1. Microcontroller

The microcontroller is perhaps the most important component of the design. It is crucial that a microcontroller is picked that can handle all of the peripherals needed for the design of the alarm clock. Other things that need to be considered are cost, ease of implementation, ability to reduce complexity, and ease of programming. The chip that had the best features and fit the design requirements for this project the best was the PIC24FJ256GA106. The microcontroller had all

of the needed functionalities so it was picked for the final design. Some of the important features that come with the chip are listed below.

- 16-bit architecture that has CPU speeds of 16 MIPS
- Program memory of 256 KB to providing ample room for the program
- For the lowest pin package: 53 I/O pins
- Built-in power managed modes for optimum low power running
- EEPROM emulation capable to eliminate the need for separate EEPROM component in the circuit design
- Built-in real-time clock that will cut down on needed parts

The microcontroller needed a number of things in order for it to function properly, such as power, proper connections, HMI, and firmware.

**Power:** The required power for this part is specifically stated in the data sheet and reference guide. The supply voltage range is given as 2.0 volts to 3.6 volts. However, the microcontroller takes in a number of different voltages so that it has power to all of the different embedded components. The main voltage which goes to the pin labeled $V_{DD}$ is regulated by the range $V_{DDCORE}$ to 3.6 volts. The lower bound of this range is given as a range of 2.0 volts to 2.75 volts. There are a few other voltages that were considered but they are relatively trivial to be explained here and were considered only when actually building the circuit.

**Connections:** The connections to the microcontroller were made via the lead pins so that all of the different modules and peripherals and voltages could be sent to the microcontroller. The majority of the HMI peripherals were handled by the general I/O pins, and processed using software. The proper connections were made to all $I^2C$ devices through the corresponding pins of the microcontroller.

**HMI:** All of the HMI that was used is discussed in other sections of this paper. The main concern with the HMI in this section is that it is properly interfaced with the microcontroller. The connections can be seen in the figure above, and the processing will be made in the programming of the microcontroller. Most of the HMI are button presses, which are handled as interrupts to the microcontroller software. These interrupts are processed according to what pin the interrupt will come from. How the microcontroller was programmed to do this is discussed in the firmware section.

### 6.1.1 Firmware:

The programming of the microcontroller was done in C, as it is the most familiar to the programmers. The software was written using Microsoft Visual Studio and Microchip's MPLAB IDE. Once the software was completed, it was ported on to the microcontroller and tested using the evaluation board that was discussed in the research section. The debugging and testing phase was completely done on the evaluation board. The software for the microcontroller handles a large number of actions, each having to do with interfacing the modules together. All of

the HMI actions are processed and executed through the software. The transfer of data will also be handled through the software, as well as hardware via the connections of the lead pins. Because of the microcontroller having an embedded real-time clock, all of the alarm and clock functions are handled by software. The alarm can be set by the user and when triggered will send an interrupt to the handler which will then be processed by the software. A final write of code for the firmware is included in the appendix of this document.

## 6.2. Power

Powering the whole system is the most complicated part of the whole design. Since each element needs it's own VCC or VDD it is necessary to make sure that power is distributed correctly throughout the system so that no parts get fried. Distributing the correct power is a matter of taking the 120 V provided from a standard wall outlet and breaking it down to what we need. Since the outlet puts out a AC current the designers used a 12 V power supply that takes in a 120 V AC voltage and produces a 12 V DC voltage.

There are a lot of things that the designer needed to look at when using this AC to DC converter. They needed to make sure that they are not pulling to much current from the device because if they do then the device will fail. Once the correct DC voltage is obtained the designers then needed to take this power and distribute it correctly. The power need but each device is specified in each parts data sheet. Matching these to the correct current in power will keep the parts from getting destroyed.

Once everything is powered correctly then making the interconnections between each part is a whole lot easier. Without powering the device correctly it will not work at all and the project will be a failure. Incorrectly implementing the power and destroying parts will greatly increase the cost of the product so doing it correctly the first time is essential to keeping cost low.

The power supply that was created for this project was a variable power supply that took in 12 volts and converted it to the voltage needed for the design. The voltage output was set to 5 volts to power the USB connector for the projectile connection. The 5 volts provided was stepped down to 3.3 volts using zener diodes to use for the other peripherals.

## 6.3. Clock

This section is very dependent on which microcontroller was picked for the final design. The microcontroller selected was the PIC24FJ256GA106, which includes a built-in hardware real-time clock. This means that the clock was programmed via the microcontroller, as well as the alarms being programmed and handled by

the microcontroller. The only extra component that needed to be supplied was the crystal oscillator to supply the frequency. The required frequency for the real-time clock and calendar module of this microcontroller is 32.768 kHz. This crystal was connected to the microcontroller via the oscillator input pins. The microcontroller was programmed to allow the user to set the clock and alarm through the use of momentary button switches.

**HMI:** The user will need to set the clock and the alarm through use of simple push buttons. These buttons are mounted to the housing, and the signals will be sent to the general I/O pins of the microcontroller. The buttons that were used for this were found on SparkFun Electronics' website. The size and shape of the button can be seen in **Figure 6.3.1**. There were three buttons to cover hours, minutes, and alarm.

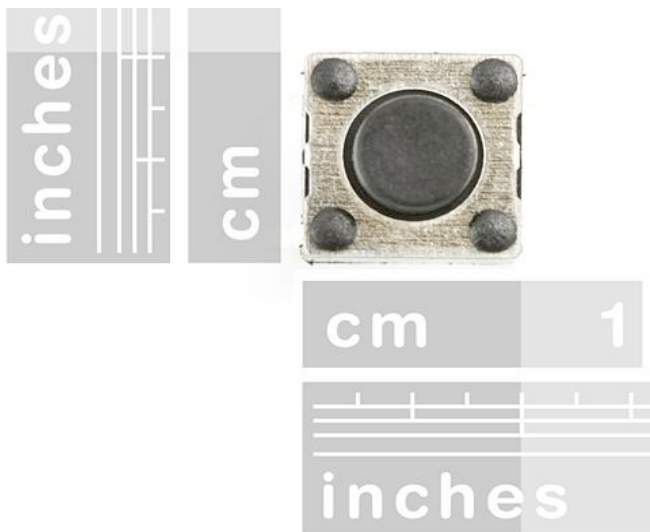



**Figure 6.3.1**
(Reprinted with permission from SparkFun Electronics)

Depending on the functionality that the designers wish to present to the user, more or less buttons will be used in the final design. This will be amended in future versions of this document.

The majority of design for the clock went into the designing of the microcontroller because the microcontroller is what houses and controls the clock. Some of the designing can be seen in the schematic portion, like the connecting of the crystal and the HMI as well as all of the outputs for the screen, which is described in its on section. Therefore, most of the clock design will be described in further detail in other sections of this paper as described above. The schematic for the interface of the HMI and the crystal to the microcontroller can be seen in **Figure 6.3.1** below.

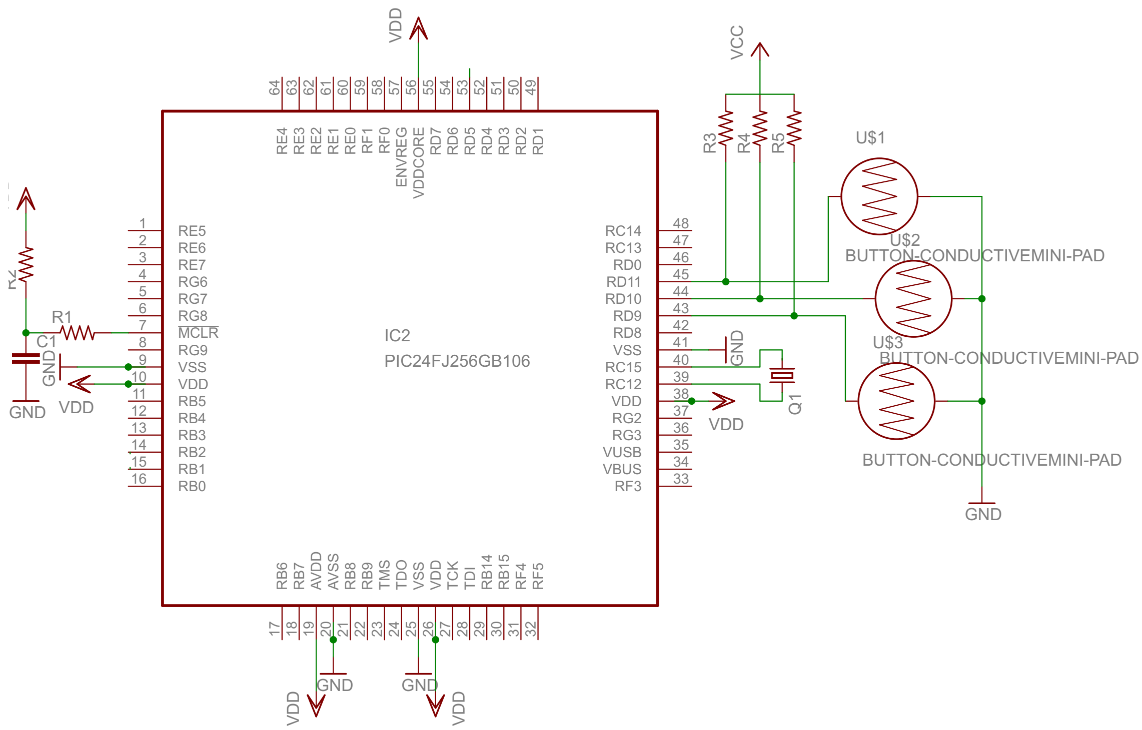



**Figure 6.3.2**

Schematic for microcontroller with crystal and HMI for clock

## 6.4 Display

The display chosen for use in the project is the Silicon Craft SC2004. This display receives data from the microcontroller serially and displays it to the screen. It is programmed to show big numbers as time after a certain period of time that the clock is left alone or when music is not playing. The SC2004 has the ability to display normal alpha numeric characters and special characters.

All the commands sent to the display are simple hex commands. Things such as cursor controls, backlight controls, and delete commands all have there own preset hex code for easy implementation. Custom characters can also be created for use on the display. This will allow us to display anything we need to display on screen.

Software for testing and programming the display is available through the manufacturer's website. It show what instructions are being sent to the display and what response is returned from the display. This was essential to learning what commands to send to the display to display the correct things to the screen. That way we could test everything out before we interface the display with the whole system.

## 6.5 Internet Connection

The decision was made for the alarm clock to connect to the internet via an Ethernet connection. This saves the designers (and the users) from worrying about data being lost by a poor connection. It saves the worry of data being sent to the wrong location as is theoretically possible if there were multiple Bluetooth connections happening within the alarm clock base, its speakers, and the computer. Also, Ethernet is an established technology. Unlike Bluetooth and Wi-Fi, which are relatively newer by comparison, Ethernet has been around for a while. Technologies involving Ethernet have already been created and tested and proven and implemented in many different ways by many different people and it would not have to be designed or redesigned for the alarm clock's needs. Choosing Ethernet was choosing to accept what other people have done and use that knowledge to improve the alarm clock. Ethernet was a conservative choice of safety and reliability over new wireless networks.

The microcontroller decided on is one of the PIC microcontrollers from the company Microchip. The PIC brand of microcontrollers (minus the new PIC32 models) do not come with a Ethernet connection straight out of the box. Because of this an additional part had to be bought and attached to the microcontroller to make this connection between the Ethernet data and the microcontroller. The ENC28J60 is the specific Ethernet controller that was decided on by the design group. It has a MAC module that allows the Ethernet controller to conform to IEEE's 802.3 standards, which means it should work with any of the alarm clock user's home network. It is built to work on its own, but it has a Serial Peripheral Interface bus (technically a SPI serial interface) so it can connect to other electronic devices.

Below is a schematic done by someone (DJ Delorie) who had to interface the ENC28J60 with some other Microchip parts (a larger version is seen in the appendix). Microchip's website offers a similar schematic that has less detail than what DJ Delorie did, as it is more of a generic image. Needless to say, this schematic is what the design for the exploding alarm clock was planned to look like. All the parts are clearly labeled, as to what measurement they are and what they are connected to. The pins on the left side are the connection between the microcontroller and the Ethernet controller. The right side is the connection between the Ethernet controller and the actual Ethernet cable. This will complete the Ethernet interface. The needed resistors and capacitors and other minor parts (again, whose measurements are already given in the schematic) could be easily be purchased at a store like Radioshack or sites like allelectronics.com or mouser for a relatively small price.

Unfortunately, when the time came for the designers to implement this internet connectivity, time and costs constraints prevented it from being realized. Were more time and money to be given, the designers would have gladly added the internet connectivity to the exploding alarm clock..

Schematic of a circuit using the ENC28J60 **Figure 6.5.1**.

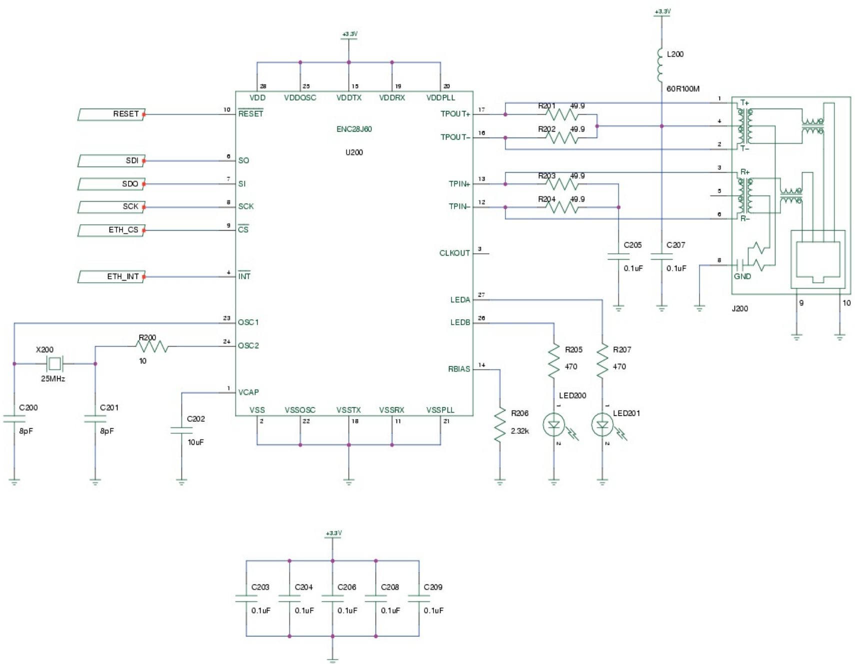



**Figure 6.5.1**
Permission pending

## 6.6. Radio

In order to implement the radio in to the design, a simple FM tuner chip was added to the circuit, along with an antenna to receive signals. The part that was found to fit into the design the best was the SPK-TFM-1010 from SparkFun Electronics. The breakout board had the best features and a reasonable price, as well as the most unique design at of all of the researched parts. The main reason this part was chosen was the fact that it had everything it needed built-in to the breakout board, except an antenna. The loss of AM functionality was regarded as negligible, because having the FM radio was sufficient for this project as radio is not the main focus.

**Power:** This part came with a data sheet that holds valuable information about connecting the board to a circuit. The power is an important part of designing a circuit, because it is what makes the circuit work. However, it can also damage the system if used incorrectly. The supply voltage is given in the data sheet as a range to stay within. The range to stay within is 2.5 volts to 3.6 volts. The voltage that was supplied to this part depends on the power supply chosen, which is described in another section.

**Connections:** The connections for this part are relatively simple because of the small number of pins. The part only has 10 external pins, some of which do not need to be connected depending on what kind of interface that is being used. The first pin is the antenna pin, and was connected to a simple wire to help pick up signal. An actual antenna was going to be used, but for this project it is not necessary for the main function of the alarm clock. The second is not connected, while the third and fourth pins go to the speakers. Then pin 5 goes to ground while pin 6 is set to the supply voltage. Pins 7 and 8 handle the interfacing, and vary depending on which type of interfaced is used. This was decided and added to the final schematic at the end of the design phase. The last two pins connect to the microcontroller, 9 goes to the clock and 10 goes to the data line. The schematic for this part being interfaced is shown in **Figure 6.6.1** below.

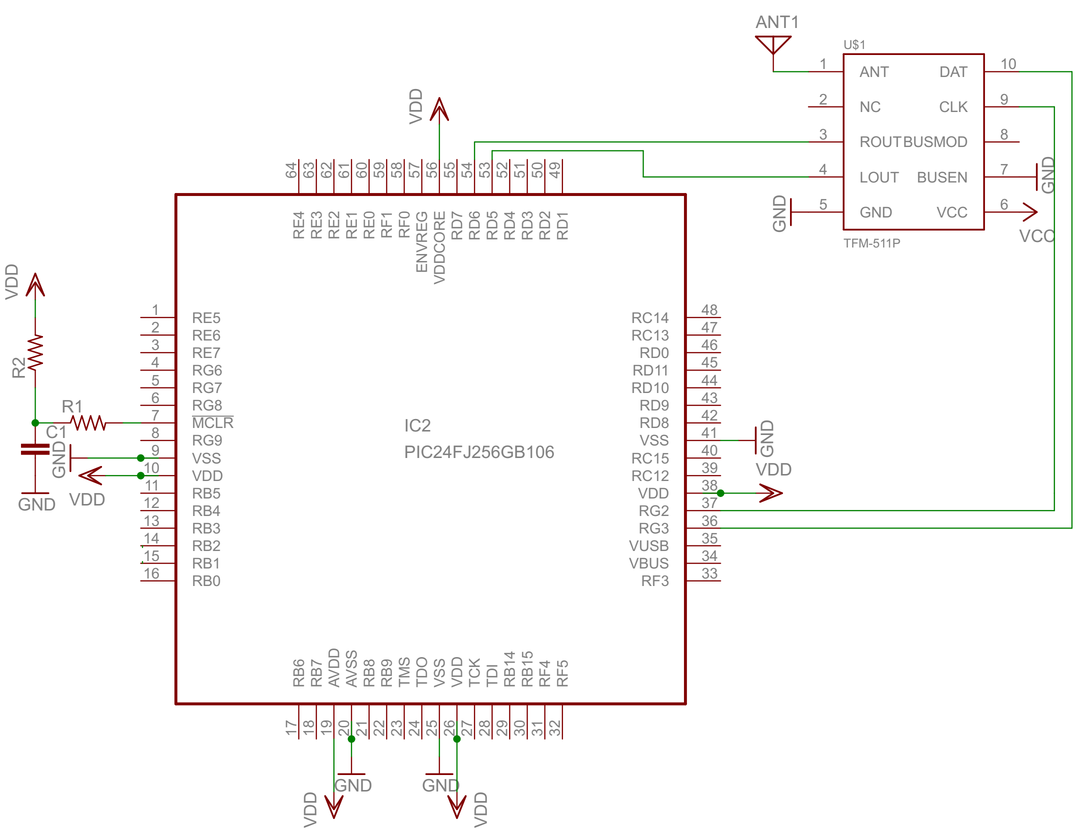



**Figure 6.6.1**
Schematic of the Radio

**HMI:** The controls for the radio are very similar to that of the MP3 player, with some minor adjustments. The main changes will take place in the coding of the microcontroller to account for the different mode. Obviously the buttons do different things, such as the track seeking buttons will now seek through the radio frequency. However, the general layout and scheme of things are exactly the same. The microcontroller is aware of what mode it is in, either radio or MP3, and

changes the outcomes of button presses accordingly. The schematic with the HMI included can be seen in **Figure 6.6.2**.

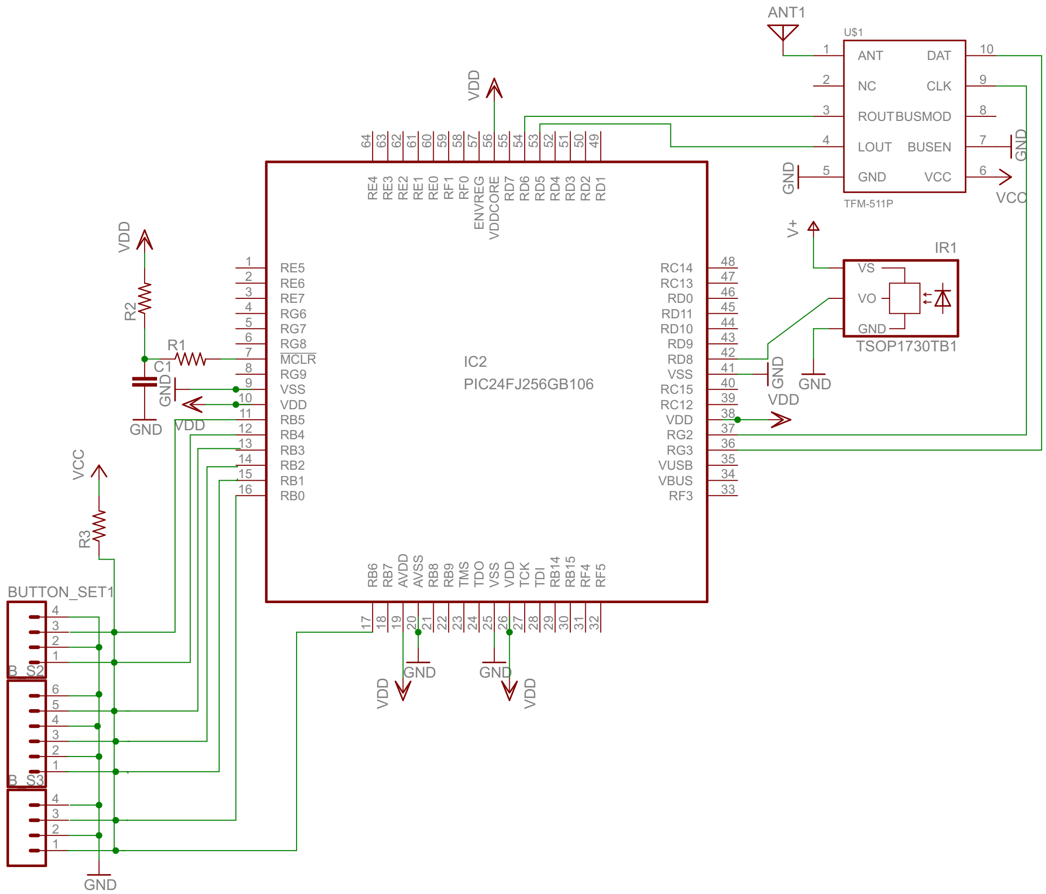



**Figure 6.6.2**
Schematic of the Radio + HMI

## 6.7. MP3 Decoder

The selection of the MP3 decoder took in to account a number of desired features and limitations that were required for this project. There is a need for interfacing with USB and SD cards, as well as playing MP3 encoded files. It would also benefit the final design to include other compatible file formats to give the user versatility when choosing music files to use. The MP3 decoder chosen offers all of these and more. The BU9438KV from Rohm Semiconductor has everything that this project needs, along with some extra features that will benefit the user. The main feature that pushed this chip to the top was the built-in interface with USB and SD, that would reduce complexity in the final design. It also comes with a built-in DAC to eliminate the need for an external one, so that the MP3 decoder can be directly interfaced with the speakers. When

implementing this chip into the final design, there were a number of important things that need to be considered.

**Power:** The supply voltages are very important to the design of the chip, because without them the chip will not function at all. However, it is also of utmost importance that the right voltage is sent to the chip, so that it is not overloaded, or does not receive enough. The specifications for the voltages are given in the data sheet of the part. The range that is given for the supply voltage is 3.0 to 3.6 volts. The preferred setting for the power would be around 3.3V, which is what this project uses. This is supplied via the power supply circuit that is described in the power section. Not only does the chip need power to the main voltage-in but it also needs power to all of the different components involved. There are a number of warnings concerning the power of the system that need to be heeded when setting up the circuit. The power supply might cause a current rush when it is first turned on, causing a small delay in the IC, if two or more power supplies are used. This delay will not do much to effect the circuit in a serious way, but it needs to be noted with the built system. Also, the data sheet has warnings stating the need to keep the ground lower then all of the other voltages.

**Connections:** The chip is interfaced with a number of different peripherals in order to assure that the transfer of data flows correctly. The chip is connected to the SD card slot and USB slot, which are both described in the Memory storage and Interfacing section. The pin printout aided in connecting these to the proper leads. Also, because of the built-in DAC, this chip was able to connect directly to the speakers. These connections were made through the outputs of the embedded DAC. The microcontroller sends data signals to the MP3 chip to tell it when and what to do. The microcontroller receives some of these commands through the use of HMI, which gets direct commands from the user. The HMI will be discussed later in this section as it directly relates to the MP3 functioning. The microcontroller sends its data through the use of general I/O pins and the MP3 decoder receives the information in the same manner. The power supply also needed to be connected in order for the chip to work, but this is explained in the previous subsection. All of the proper connections for the MP3 decoder chip can be seen in the schematic diagram in **Figure 6.7.1**.

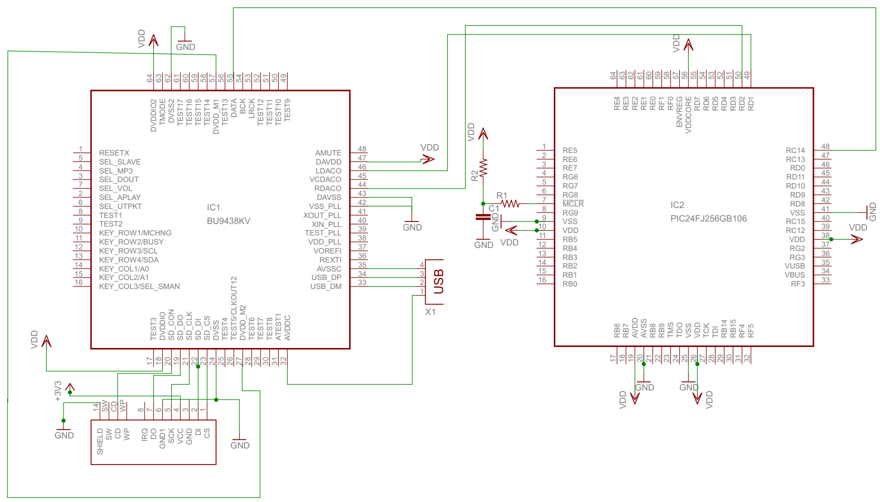



**Figure 6.7.1**
Schematic Capture for MP3 and peripherals

**HMI:** The human-machine interface allows the user to send commands to the microcontroller, letting the user control what the machine will do. For this particular design, specifically the MP3 controlling, simple momentary push switches work perfectly for allowing the user to input commands from the base. An infrared remote system will be also used to account for use from distances that would make using the buttons on the base a nuisance. The push buttons used in the design are a set from SparkFun Electronics that come with a mini button pad for 4 regular momentary push buttons and 1 directional pad. The PCB, which can be seen in **Figure 6.7.2**, was directly mounted to the housing and connected to the microcontroller for data transfer. The PCB came separately from the buttons, but all together it ended up costing around $7 which is not bad for the amount of buttons and functionality that was received.

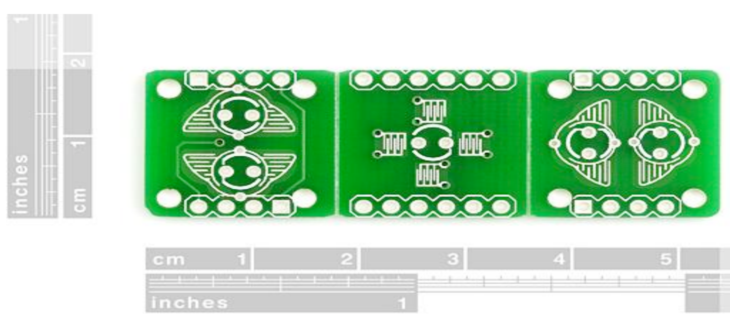



**Figure 6.7.2**
(Reprint with permission from SparkFun Electronics)

The left most buttons, which resemble up and down buttons, are used for volume control. The directional button in the middle is used for menu browsing, and play/pause functions. The last buttons on the right is used for track seeking. The remote control portion of the user control will be handled by the infrared receiver

that was discussed in the research portion. This does connect to the general purpose I/O pins of the microcontroller so that the data can be received and interpreted by the microcontroller. The programming of these interpretations was relatively simple because the actions are the same as the buttons on the base. To complement the IR system, an existing IR remote from a car stereo system that was previously purchased by a group member was used to save on cost and time constraints of building one from scratch. Adding the infrared receiver and buttons to the schematic was the easy part. This can be seen in the updated schematic in **Figure 6.7.3**. The actual programming of the buttons and remote and their resulting functions falls under the category of programming. The microcontroller and will be discussed in another section.

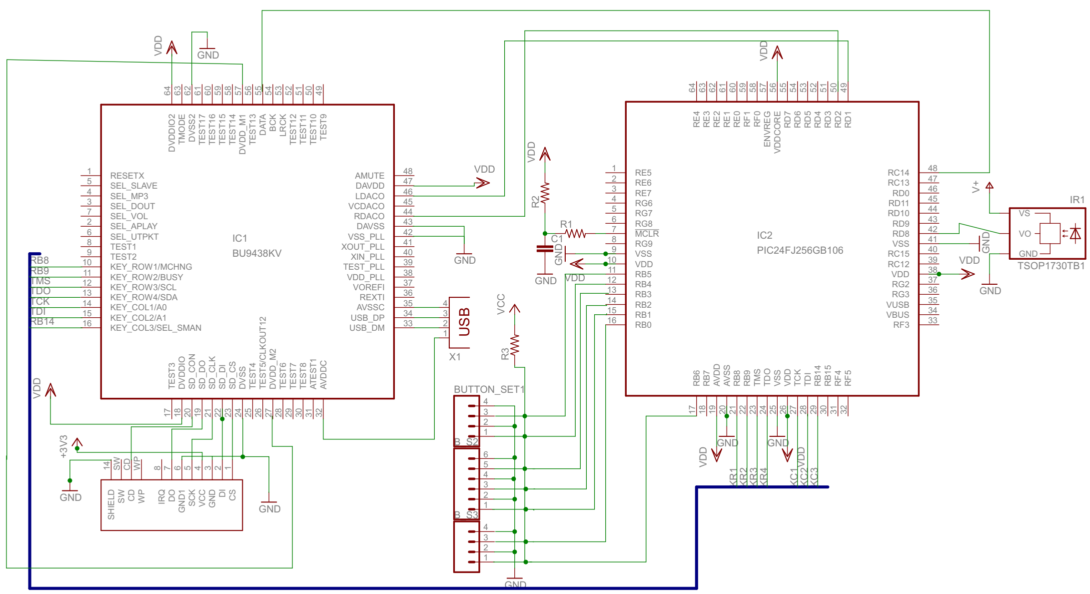



**Figure 6.7.3**
Schematic Capture for MP3 and peripherals and HMI

## 6.8. Memory Storing and Interfacing

The final design of the memory storage and interfacing for the project is discussed in the following paragraphs. The decision was ultimately decided by weighing the pros and cons of each media and interface, and searching for the one that fit our needed criteria the best. The criteria considered included cost, user friendliness, ease of implementation, efficiency, and speed. Another factor that helped decide which storage media to use for this project is the actual interface chosen. With the Atmel® chip described in the research portion for this topic, there is a possibility to use all of the storage mediums that were discussed and put up for consideration. If all of the selections are used for the final implementation then we give the consumer a chance to pick the media format

that they want. Some of things to keep in mind when designing the base housing for the clock is to account for all of the ports needed to accommodate all of the different kinds of storage devices if it is decided to use all of them in the final implementation. Even if all of the storage devices are not used the two best solutions for interfacing seems to be the AT32UC3B0256 made by Atmel® and the BU9438KV. The first part of this section will discuss the main reasons why to use the AT32UC3B and the BU9438KV will be discussed after that. The final part of this section will discuss which chip the final design holds.

**AT23UC3B:** The AT32UC3B chip is small enough to fit into our design, and has the capabilities of interfacing with all of our possible storage devices. It also comes with application notes, provided by the Atmel® website that would help program the microcontroller to act as an MP3 decoder and an interface to the storage media. In fact, the application note has the interface already laid out for SD flash cards and USB mass storage flash drives. The main changes that will be made to the program are the user controller process, which will be changed from key commands to buttons and dials, and the addition of iPod support. The user control changes entail linking the buttons and switches to the proper pins. The addition of the iPod controls could prove to be difficult, because it involves a large change to the programming of the application to the chip. It also involves creating a customized cable which will be done by following the pin print outs and descriptions found in the research section. The AT32UC3B0256, or AT32UC3B as it will be henceforth called, is a chip that can provide an already built in interface for USB and SD cards through the application note provided. The block diagram in **Figure 6.8.1** shows the general idea of what the chip does in reference to interfacing the storage media and outputting sound. The reason that it shows the output as going straight to an amplifier is because of the built-in MP3 decoder through the use of the application note. The controller in this diagram will be replaced with buttons and dials, and the GUI will be replaced with a display on the face of the clock, that will show minimal information about what song is playing, and what storage media it is using. Also, the headset in this diagram will be replaced with the speakers for the alarm clock. The rest of the inputs shown, such as the clock and the SDRAM, will be handled by the main microcontroller, which is discussed in its own section of this paper.

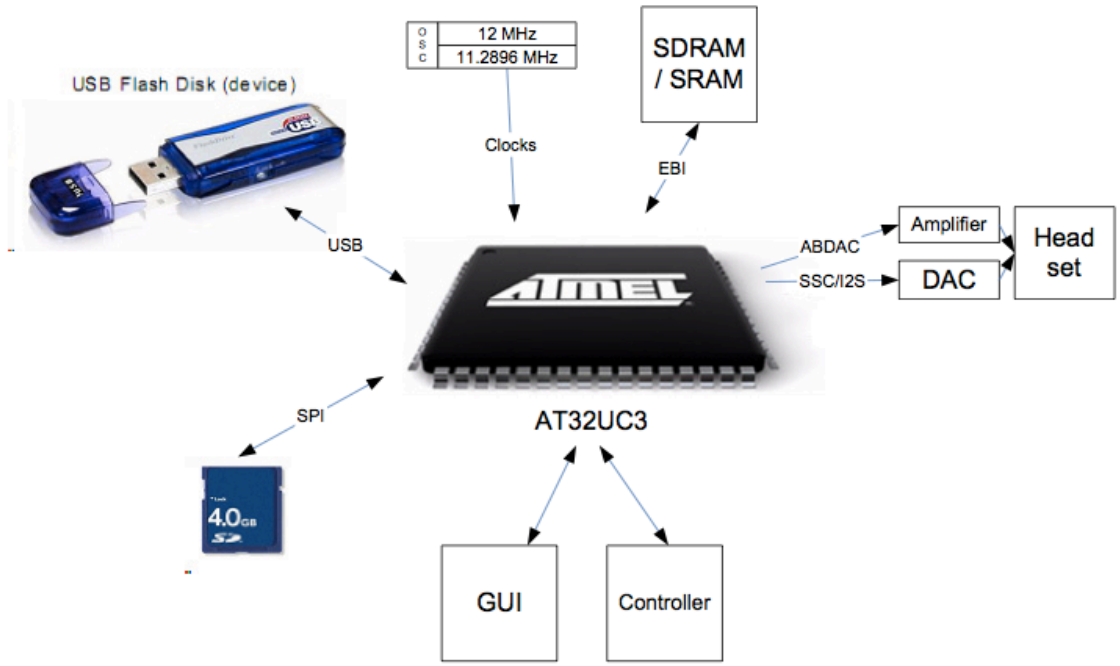



**Figure 6.8.1**
(Reprint with Permission from Atmel)

As for the chip itself, the features included are listed below.

- Performs at 1.38 DMIPS/MHz
- Includes a Memory Protection Unit
- 7 Peripheral DMA Channels which improves speed for peripheral communication
- Internal High-Speed Flash of 256K Bytes
- Internal High-Speed SRAM of 32K Bytes
- USB 2.0 Full/Low Speed and On-the-Go
- 64-pin TQFP/QFN which includes 44 general purpose input/output pins
- Single 3.3V Power Supply or Dual 1.8V-3.3V

With all of these specifications in mind, the implementation of the microcontroller in the design is feasible. The pin print out and descriptions are necessary to map the connections correctly so that the components interface with the microcontroller properly. The pin print is supplied in the design specifications for the part when it is purchased. **Figure 11.2.3** in the appendix shows the physical layout of the pins so that it is possible to physically attach the connections properly. The dot in the bottom left corner signifies the actual dot on the chip, so that it can be used as a reference part to know where the pins start counting. With the pins displayed spatially, descriptions are required to determine what needs to be tied to the pins. The data sheet for the part also had this available. The pin descriptions are shown in **Figure 11.2.4** in the appendix and contain valuable information on how to connect the microcontroller to the peripherals and other needed devices, such as voltages, and grounds. Combined with the pin

print out, the description table will enable the design of a block diagram for this specific application in the project. Not all of the pins will be used for the design because we are using this multipurpose microcontroller for one specific application. The important thing to note when viewing this pinout is that all of the pins labeled GND need to be grounded, and all of the voltages need to have the proper voltages in order for the chip to function properly. Even with all of the pin descriptions, there is still a need to interface the chip with the computer for software development and debugging. This is handled through the use of a development board. They act as an interface to the PC so that the user can export their software that they have written and compiled to the board. The board will also act as a debugging test unit, so of them even have LCD read outs to display debugging data. This is an essential tool to getting the microcontroller to do what you want it to do. The development board will be discussed further in the microcontroller section of this paper.

**BU9438KV:** The other chip in question is the BU9438KV decoder chip. This is mainly an audio decoder but it comes with the interface for USB and SD cards built in. So like the AT32UC3B, it would combine the interfacing and the decoding into one. The ease of implementation between the two chips is strikingly different. The audio decoder comes with all of the interfacing and decoding preloaded and therefore needs minor tweaking to get the chip working for the design. The documentation that goes along with this chip is also another selling point because of its simplicity and lack of unnecessary data, like the AT32UC3B. The pinout and the pin description are needed for the implementation and can be seen in **Figure 6.8.2**. The figure also shows all of the integrated parts of the circuit, showing that it has the capability of handling all of the needed functions for the design.

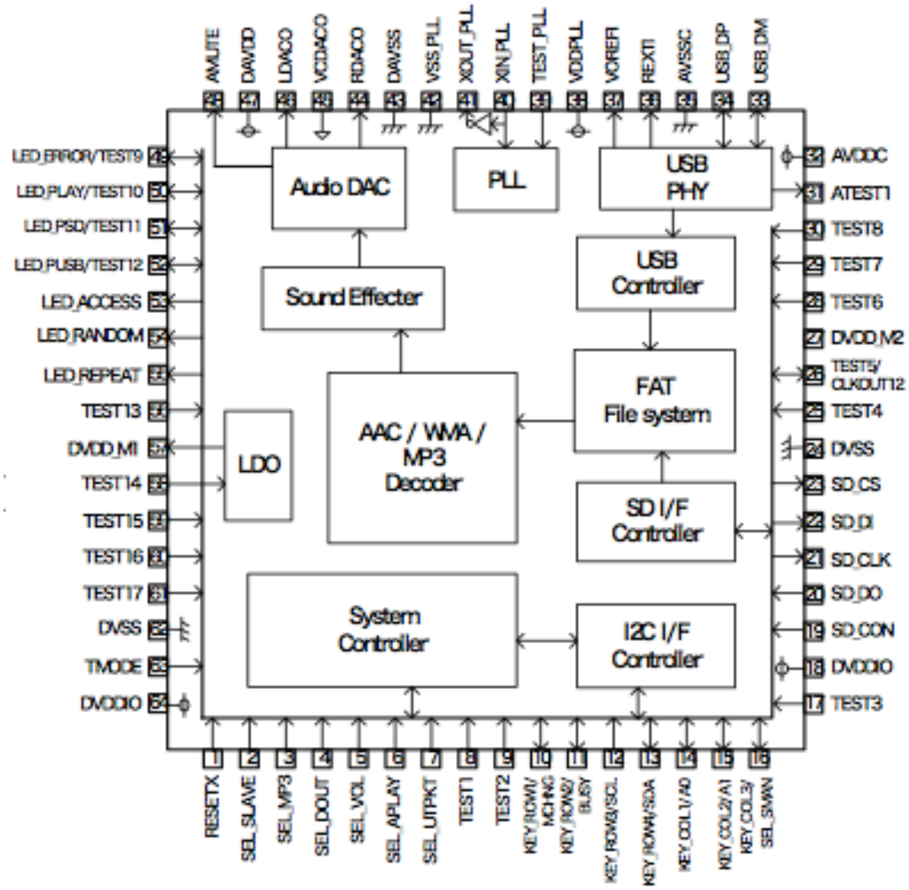



**Figure 6.8.2**
(Reprint with permission from Rohm Semiconductors)

Using these schematics the final design can be made to interface the USB and SD card correctly. The two interface designs in question both have their pros and cons and can be used for USB and SD. Ultimately the choice goes to the option that is easiest to implement and has the best features. That chip would be the BU9438KV, which was implemented in the final design of this project.

**USB Socket:** Another important part for the interfacing portion is the actual USB socket. This socket was attached to the board and connected to the microcontroller so that the USB can send its data through the chip. To do this the pin print out for the USB connector socket was needed so that the connections could be made correctly. The pin print out shown in **Figure 11.2.5** in the appendix, along with the physical layout, enabled correct implementation of the USB interface. The part needed to make this possible is called a USB Type-A female connector. They are very inexpensive and are composed of a USB socket with 4 lead connections. This part was found for only 57 cents and its number is HWS10492. Along with the USB socket is the socket for SD card reading.

**SD Card Socket:** If SD was to be implemented as a feature for mass storage of music files then it needs to be physically interfaced to the microcontroller through the use of a socket. This socket is very similar to the USB socket except that it is for SD cards, and the pin count is different. The pinout of a SD card is shown in **Figure 11.2.6** in the appendix. The figure also shows the physical layout of the pins in reference to the SD card itself. The pinout table shows the pin descriptions for two different modes of the SD card, SD mode and SPI mode. The mode that is used for this implementation is the SPI mode which has separate serial in and serial out. With all of these designs and pin print outs, it is possible to implement a schematic design that shows the components connected together. The schematic, seen in **Figure 6.8.3**, shows how the hardware was interfaced, specifically through wires connecting the pieces dealing with the mass storage of MP3 files with the microcontroller. This block diagram was used to implement a final design diagram and eventually the final working prototype.

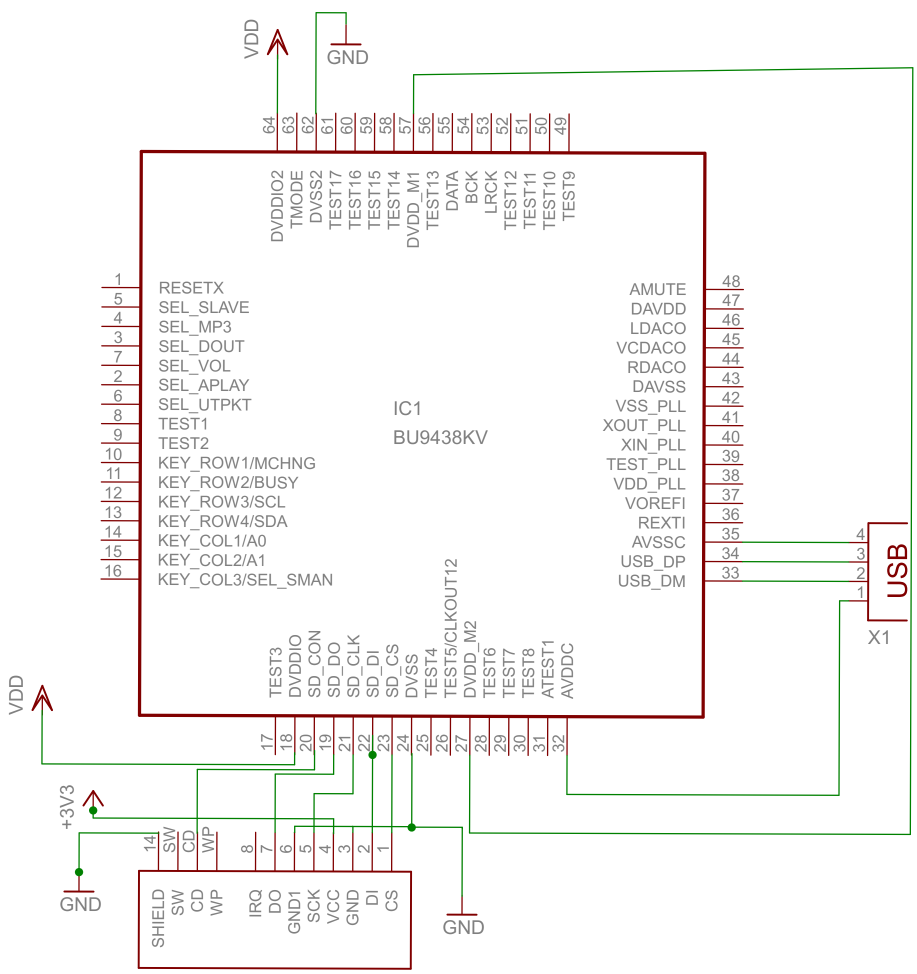



Figure 6.8.3

## 6.9. Launcher

It was decided that the speakers are launched by a spring system. The spring gives the best "explosive" effect compared to all the other possibilities. It has no clean-up after the alarm like the water pressure launching system would. There is no extra purchases needed, as in the case of the gas pressured launching system. A spring launched system would be more powerful than a fan launcher system (and certainly much less noisy), and without the threat of one or more spinning blades that could injure the user of the alarm clock.

With a spring system, a spring was obviously needed. The best choice was going to be a compression spring. The "power" from the spring comes from the pressure on the spring, keeping in place. When the pressure is released, the spring flies forward with its full force. It was decided that we would use a Beryllium Copper compression spring. It is resistant to corrosion, resistant to fatigue, and is non-magnetic. The spring has a spring constant of 11.6 inch pounds, an uncompressed length of 1.58 inches, and a compressed length of .504 inches. Using Hooke's law (F= -k*x), the force this spring exerts when released from compression can be calculated. K is 11.6 inch pounds and x is 1.58 inches - .504 inches, which results in 1.076 inches. 1.076 inches * 11.6 inch pounds is 12.4816 pounds. This is a good amount of pressure, enough to move the speakers a good distance across a table, or wherever it is that they are situated. At the end of the spring is a one inch by one inch square piece of wood, the same thickness as that of the housing (one-eighth of an inch). This helps concentrate the force from the expanding spring to a point of the designer's choosing. It also helps focus the point of the force on the speaker (as the square piece of wood will hit the speaker when the spring is released). The square piece also helps when the user is attempting to reset the system. It gives them a point to concentrate the pressure of their pushing on. Not only that, but it will protect the user from any spring related injury, as the only "endpoint" of the spring is attached to the piece of wood and inaccessible to the user.

The speakers, in order to increase the distance they move when they are struck by the spring, one idea was to have miniature wheels at the bottom of the housing. When the speakers are struck, the wheels will cause the speakers to roll further along the path of the spring's force. Not only that, but it will save the table (or platform) that the alarm clock is on from any damage from the speakers being pushed across them (scratches and the like). These wheels will have to be embedded into the housing (in order to prevent them from just popping off when they hit the ground. Tiny slits would be made in the bottom of the speaker housing to hold the two wheels per speaker. However, these wheels were excluded from the final design.

The alarm clock "stops" (as in the alarm stops going off) when the contacts from the power supply to the battery charger are connected. The system sends a

signal to the MCU telling it that the speakers are attached, once both contacts (one from each speaker) are connected to the base of the alarm clock. The base of the alarm clock also has a small protrusion on each side, ever so minutely angled up, to set the speakers on. This fixes the issue that some users may have of the speakers rolling when not in use. The angle will keep the speakers from rolling back, and keep the connection between the contacts from being lost. This is also the reason that the speakers will be shorter than the base section. It allows for the speakers to “fit in” the space left over between the protrusion and the top of the base. It would look better to have the base taller than the speaker than to have the speakers taller than the base.

There is obviously a way to keep the spring from immediately expanding once the user stops putting pressure on it. The way decided on, for simplicity’s sake, is a solenoid system. There will be two three inch metal ram connected to the base of the alarm clock, one on each side. They will not be directly connected to the top of the base as they need to have room to move up and down. There will be a small low powered solenoid inside the base of the alarm clock. It is a small (no longer than three inches) and light weight (only 1.6 ounces) solenoid, perfect for use in an embedded system such as this. This solenoid will be connected to the metal ram and when the alarm goes off, the metal ram is pulled in by the solenoid. The solenoid is connected to the metal ram via springs.

The solenoid receives a signal from the microcontroller to turn on when the alarm goes off. This pulls the ram in and lets the wedge go, allowing the spring to push the wedge up. This will launch the speaker from its platform. The solenoid stops getting power within a few seconds, so the ram won’t have the time to start to head in the downward direction (as that would cause it to hit the elongated spring). When the user goes to reset the alarm clock device, he (or she) will press the speaker against the spring, compressing it. When the speaker and the spring are pushed back as far as they will comfortably go, the metal ram blocks the wedge, keeping the spring set in place.

## 6.10 Wireless Technology for Speakers

The designers decided to use bluetooth for wirelessly transmitting the audio to the speaker. The device that was chosen to implement this is the WT32 Bluetooth Audio Module. By setting one WT32 to source mode the designers were able to transmit a stereo audio signal of audio. Then the designers placed one WT32 at each speaker in sync mode. The ones in sync mode picked up the streamed data and passed it along to the speakers.

In order to pass on this data the receivers send the information they get over usb to the speakers. The wireless devices use the A2DP to transmit audio from one device to the next. This device also has an internal battery so that it can be connected to a battery charger. That way once removed from the base, the

wireless speakers continue to function without the need of an extra battery. The design for the battery charger is provided on the Blue Giga website.

Using the pinout in **Figure 6.10.1** the designers hooked up each element for the transmitter in the base station. The designers connected audio in left and audio in right from the MP3 decoder. The designers created the battery charging circuitry each WT32 uses and connect them to the VDD_CHG and VDD battery pins. For connecting to the speakers the designers used the USB_D - and USB_D + pins. This allows for easy and quick connection to the speakers. Everything else for this device is controlled by the software that comes with the device.

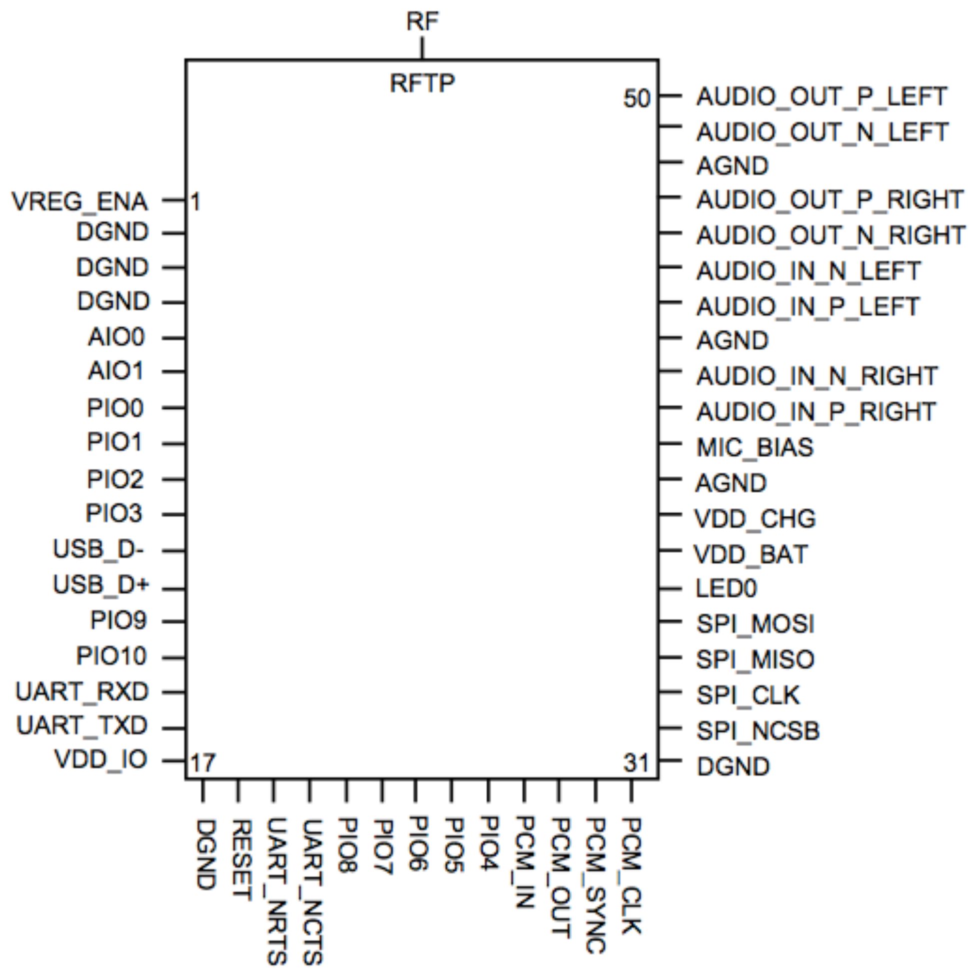



**Figure 6.10.1**
(Reprint with Permission from Bluegiga)

## 6.11. Battery and Charger

The battery type that will do the best work and be the easiest to work with is the Alkaline battery. However, the choice of Alkaline presents a problem: rechargeable Alkaline technology is almost non-existent. A quick google search

shows that most of what is out there is people talking about recharging disposable Alkalines, not rechargeable ones. So unfortunately, that takes rechargeable Alkalines out of the equation. Lithium-ion batteries are powerful. In fact, they are some of the most powerful batteries out there. They also don't have to deal with any memory issues like other battery types. But Lithium-ion batteries also are expensive. Not only that, but they present a danger to the user of the alarm clock. A Lithium-ion charger would be expensive as well, because it has to be accurate in its readings. More accurate than that or Nickel based, or Lead-acid chargers, due to the inherent instability involved with Lithium-ion technologies.

Lead-acid batteries are in use and are a mature technology. Therefore, there a lot of applications using lead-acid batteries, and they are popular, but they are also very big. Their main use is as car batteries and that doesn't sit well as a consumer application, like powering the speakers in an alarm clock. The battery would end up being larger than the entire system! Its charge time is long at 14 hours, but there is no added complexity in the recharging process like there are with some of the other battery types.

What that leaves is Nickel-based batteries. Nickel-based batteries are quite mature, being one of the oldest types out there. They have three types of chargers, so there will be more choice there. Their price is not bad, but their energy density is not that great either. Nickel-cadmium charges fast, has a decent battery life, and a pretty long lasting overall life. However, they contain toxic materials so their usage has to be handled with care. They also have memory issues, so that has to be taken into consideration. Nickel-metal hydride batteries have a very complex charging process, so any designs would have to make sure to take all the charging limits into account. They also take a bit longer to charge than Nickel-cadmium. But the energy density is larger than Nickel-cadmium and it doesn't have any toxic chemicals in its make up (like Nickel-cadmium does). In the "pro" category, Nickel-metal-hydride batteries have less to worry about when it comes to memory, so there is less chance of the battery suddenly "forgetting" how much energy it can actually store.

The design for the system is best suited with a rechargeable Nickel-metal-hydride battery. Nickel-metal-hydride batteries come in all sizes and shapes (like disposable alkalines). So the next decision is how much power is needed to power the speakers. The style of the battery (AAA or AA etc) is not important because all that matters is the energy density. The same density can be found in either shape. You can even get C batteries that are just high density AAs with a casing. To be safe, the choice for a battery should be 2500 mAh AA rechargeable Nickel-metal-hydride battery. That is a good mAh number (it is a little less than that of an Alkaline AA battery); that should last far longer than any user would be using the battery for.

Each AA Nickel-metal-hydride battery has a voltage of about 1.2 V. So putting three of these batteries in series would give the equivalent of a 2500 mAh 3.6 V battery. The speakers are essentially large wireless headphones. Other portable speaker systems use four AA Alkalines (with a voltage of about 6V) to power an entire system. The alarm clock speakers only have to power the individual speakers and the wireless receiver. The wireless receiver is pretty light on the power needed, as things like Bluetooth headsets are able to go for extended periods of use on a battery small enough to fit in the headset.

In fact, the simplest explaination on how this charger and battery system works is that of a cordless phone. Most cordless phones have a battery pack system that is okay for use for a minute, or for an hour. It gets recharged every time it is back on the base station. The cordless phone scenario has some similarities with the alarm clock idea. As stated, they both had battery packs that need recharging. Both only need to be charged when connected to the base station. Both of them have valid uses that take a few moments, or can take multiple hours. And both of them have a signal that is transmitted from the base to the cordless parts that is output through a speaker system.

The controller chipset that was used for the battery charger is the MAX712 controller from MAXIM-IC. This was used for one very simple reason: there aren't really any other charger controllers out there. Yes, there are some, but the MAX712 is the only one that has valid resources for it (and there are many examples out there of complete circuits used for battery charging purposes). In fact, one of the applications of this chip is in cordless phone charger systems. It charges both types of Nickel based batteries, so just incase the Nickel-metal-hydride battery did not work out, there is still a chance that the system would have still worked. The MAX712 does fast charging and trickle charging, without any input from the user (or any set up by the designers). It uses zero voltage change to determine when to end fast charge and temperature to determine if the battery has been overcharged. The MAX712 also is smart enough not to start charging if the temperature of the batteries is too high. If the batteries had just been used (and were therefore heated up), the charger would not immediately start charging them; It would wait until they cooled down.

Below is the generic operating circuit that MAXIM provides for use of the MAX712 controller. The designers used this circuit as the design for the charger for the alarm clock. The only "change" that was added on was the power input from the base of the alarm clock, as opposed to straight to a wall cube. Most of the design had already been determined for optimal use by MAXIM. There are a few parts that the alarm clock designers had to determine, $R_{sense}$, R1, and $I_{fast}$ (the current used during fast charge). $I_{fast}$ is equal to the battery capacity (mAh) over the charge time (hours). The battery capacity is 2500 mAh and the charge time, for safety's sake, should be 4.4 hours (the max charge time). That gives 2500 mAh/4.4 hours, which equals 568.182 mA. The R1 voltage is given by the minimum wall cube voltage – 5V over 5mA, so with a wall cube voltage of 6V (the

minimum that works with this chip), that would give a value of 1K Ohms to the R1 re25sistor. Finally, there is $R_{sense}$. Its equation is determined by .25V divided by $I_{fast}$. .25V/568.182mA equals .44 Ohms.

The illustration below is a typical design circuit using the MAX712 chip. **Figure 6.11.1**

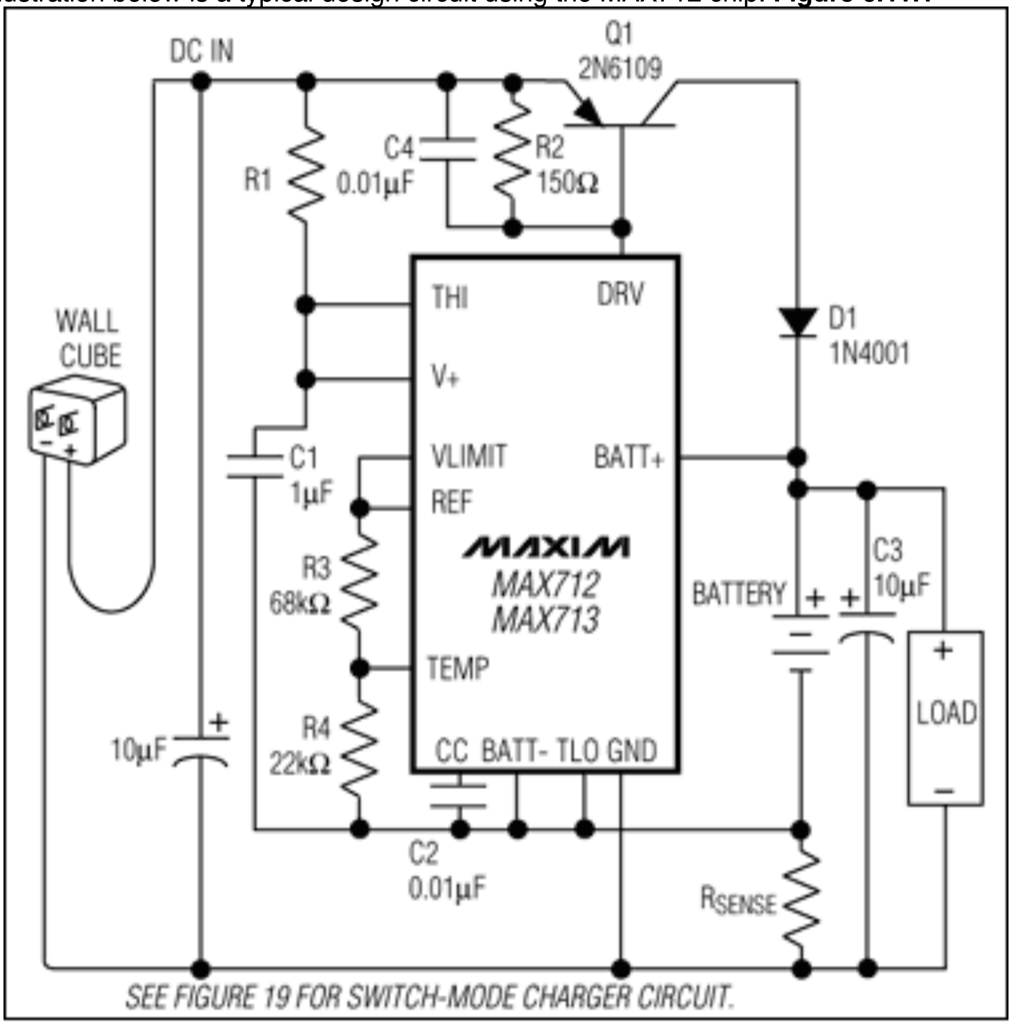





**Figure 6.11.1**

## 6.12. Battery Indicator

Next in the design process is the battery indicator light. MAXIM-IC provided yet another set of technology that will help with the exploding alarm clock. They have a product called the MAX9030, a single comparator. The MAX9030 is a small device, and uses very little power. Only .05µA is used in shutdown mode and 35µA when in active mode. So there are no worries about a low battery LED that furthers the low battery condition. The MAX9031 is a valid alternative, if for some reason the 9030 model is suddenly unavailable. The only thing that makes it different is its lack of shutdown.

MAXIM-IC has already designed a circuit that turns on a LED when the battery voltage falls below a certain threshold. It is set up to use a very low amount of power, and to be simple to connect to a larger circuit. The image below is the circuit that MAXIM has designed, and the circuit that will be built for the alarm clock's low battery indicator. There are six parts whose values are specific to the design of the alarm clock, R1, R2, R3, R4, R5, and C1. Using the following equations, every one of those variables can be solved for. Duty Cycle= $t_{ON}/(t_{ON} + t_{OFF})$, $V(t) = V(1 - e^{-t/RC})$,
$t_{ON} = -R_5C\ln(1 - V_{TRIPHI}/V_{OUT})$, $V_{TRIPHI} = V_{OUT}[R_3(R_1 + R_2)]/[R_3(R_1 + R_2) + R_1R_2]$, and $V_{TRIPLO} = V_{OUT}[R_3R_2]/[R_3(R_1 + R_2) + R_1R_2]$. $V_{out}$ is set to be $V_{DD}$, and a good data cycle (one provided by MAXIM-IC) is 2.5%. Using .025 as the duty cycle, it can be found that $t_{ON}$=.0256*$t_{OFF}$. They use values of 1V for $V_{TRIPLO}$ and 2V $V_{TRIPHI}$. From there, and using some standard numbers, you can find/decide that C1=.1µF, R1=R2=R3=1M Ω, R4=3.6M Ω and R5=91K Ω.

The illustration below is a typical design circuit using the MAX9030 chip. **Figure 6.12.1**

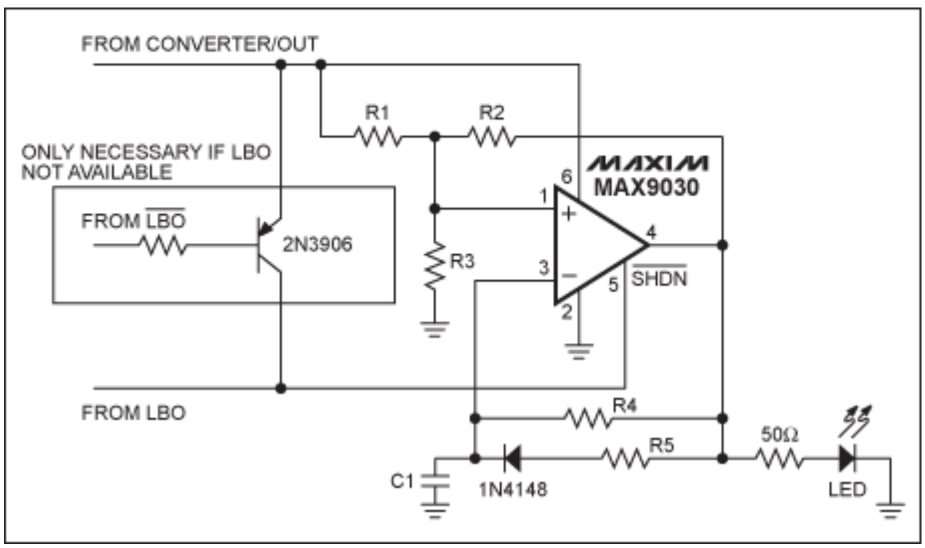





**Figure 6.12.1**

## 6.13. Housing

It was decided on that the material that should house the alarm clock should be the Polycarbonate brand Starboard. Starboard is easy to procure, as it can be bought from any local home improvement store as well as many online retailers. More important than its price is its durability. Starboard is one of the most impact resistant materials out of the ones considered for the alarm clock housing. That was the factor that was weighted the heaviest in the decision of materials. Starboard will not break no matter what damage is done to it by the constant

pressure of dropping the speakers onto the floor. It is also can be a transparent material, so it'll look good as a consumer product.

The Starboard housing is in 3 major parts: The section for the left speaker, the section for the base, and the section for the right speaker. Since the three parts of the alarm clock are three separate parts, so is the housing. The two speakers are exactly the same, as there is no difference between them. It was discussed how to properly "connect" the different pieces of Starboard that will make up the sides of each part. Generally, the speakers and the base were put together in the same fashion. The base is a rectangle shaped piece of Starboard that is connected to the "walls" of that part by a screws and dremeling. This process "cuts" the Starboard edges and combines them together. This will give a smoother looking device.

The top of all the pieces is connected with screws. The screws entered through the "walls" of the section and entered into the "ceiling" piece of Starboard. This was done in order to make the innards of the base and the speakers accessible even after final construction. Otherwise a) the designers would not be able to fix any possible errors that come up in the testing and implementation phases (as the parts would be inaccessible to the designers) b) the users would be unable to repair anything or replace the batteries or anything of that nature were something to go wrong with the alarm clock. It is always possible that a part was bad and it does no good to have the alarm clock set up in such a way that one wrong part means the clock has to be thrown away. Therefore the ceiling piece was smaller by two times the size of the thickness of the pieces of Starboard so that it fit within the wall pieces.

The Starboard to that was used for the alarm clock housing was decided to be one-eighth of an inch thick. It doesn't seem like that thickness would offer much in the way of impact resistance, but for Starboard that is a decent amount. Starboard is still a very strong material, even at one-eighth of an inch. Since Starboard is heavier than plastic, using as little of it as possible is good for weight purposes (a lighter device is a better device). A smaller weight means the speakers can be launched further when the alarm goes off. Also, the thinner it is, the cheaper it is. It would be saving the designers and the users some money by using a thin piece of Starboard rather than a thick one.

There are some differences between the housing for the speakers and that for the base, mostly due to the structure of the launching and charging systems. The base has no sections on the side. To be more specific, there are no walls on the base where the speakers connect. This allows for easier access of the launching system on the speakers (See the Launching System Design section for more details on this). The speakers also have small slits in them in order to implement the power usage of the battery charger system. The conductors of the charger system "poke" through the speaker housing and connect to the power output in the base when the speakers are connected to the base. The way a cordless

phone connects to the base is a similar method. The speakers themselves also are shorter by about ½ an inch than the base is, in order to accommodate the launcher system.

## 6.14. Explicit Design Summary

The Exploding Alarm Clock involves a technically complex design, while offering a user friendly interface to introduce a unique flexible device that will produce a marketable product. The design of the product incorporates a number of different modules in hardware that are interfaced together using software handled by the microcontroller. The microcontroller is the brain of the system that takes in all of the data lines from the modules and process them through the designers specific commands implemented through a coded firmware.

The microcontroller chosen by the design group, which is the PIC24FJ256GA106 from Microchip, is powerful enough to handle all the tasks of the Exploding Alarm Clock. Along with providing the interface for the modules, the microcontroller also doubles as the real-time clock for the implementation of the clock feature. This is complimented by a crystal oscillator which provides a frequency that is arithmetically altered to produce a proper clock signal. The signal will then be processed by the microcontroller and sent to the LCD screen.

The LCD screen that is used in the project is the SerLCD. The display is connected directly to the microcontroller so that the data being sent to the LCD from different modules is handled as processes through the microcontroller. All of these processes are controlled by the microcontroller and programmed by the designers accordingly. This display provides the user with the ability to see the time, alarm settings, and information about the media selected and playing. The information about the media is sent from the actual media device to the microcontroller and then on to the display.

The media handler is an MP3 player from Sandisk. The Sansa M240 is used to take in media files from a USB connection to a PC. The USB is directly interfaced with the player, as this is one of the built-in functions provided. This option is used in the final design to give the user more functionality out of the product. The files will be taken from the user's selected storage area and decoded through the player. The signal will then be sent to the microcontroller to be processed and sent on to the Bluetooth and eventually the speakers for audio output ideally. The prototype did not offer this Bluetooth function but instead sent the audio from the player directly to the speakers through a wired connection. Before going on to these components, the second media option will be described.

The Bluetooth transmitter takes the audio coming from a USB mp3 device or the onboard memory of the clock that has been decoded by the mp3 decoder and transmits the audio signal in stereo to the left and right speakers. The transmitter will stream all of the audio information out to the two receivers, one at each

speaker. The Bluetooth module being used for transmission and receiving are the WT32. The WT32 will be put in source mode for transmitting and Sink mode for receiving through the firmware that comes installed on chip.

At the receiver end of the Bluetooth connection the receivers send out their obtained data and send it via USB to the speakers. The iHome iHM79 speakers that the designers are using have a mini USB port for both power and data. Thorough this port it is able to charge and take in data from the Bluetooth receiver. This design is replicated in both speakers so that one can take in the left speaker signal and the other can take in the right speaker signal. This allows for full stereo audio from the base station. In order for the speakers to continue to have battery, they are replaced to the base via USB to enter a charging state. This is the ideal case that would have been implemented had the Bluetooth module not failed. The speakers are still in the design but they do not have a Bluetooth audio source.

The battery models that were chosen for the projectile are Nickel-metal-hydride batteries. They have a decent battery life, and a good amount of energy density. Their life is also pretty good. It is not the best battery type, in terms of efficiency, but what is lacks in power it makes up for in safety and cost. It is less powerful than a Lithium-ion battery, but there are no worries of it exploding when hit. Nickel-metal-hydride also doesn't have the environmental worries of the Nickel-cadmium, but with more than its power. The battery is used to signal the microcontroller that the projectile is replaced on the base. The small voltage that runs through the USB lines from the battery to the microcontroller is enough to trigger the interrupt and stop the alarm.

All of these modules will be complimented through the use of human-machine interfacing parts. There are momentary switch buttons which were found through the SparkFun Electronics website that are used to give the user control over the alarm clock and its many functions. The button pressed is sent to the microcontroller as interrupt signal calls, causing the microcontroller to process the necessary functions accordingly. Some of the different buttons that are used in the final design involve a set of momentary switch buttons to handle the alarm setting functions and MP3 functions.

The housing for the alarm clock and for the speakers is made from a readily available plastic material called starboard. With the help of James Baughman, the one-eighth inch thick starboard will be able to be formed into an “alarm clock shape”. The shaping included a chemical wielding process that allows for a smoother look to the alarm clock. Starboard is strong and very impact resistant, while still being much lighter than glass. The lightness of the housing is good, because the speakers are launched from the area where the base is. There is a spring system inside the base of the alarm clock. The Beryllium Copper spring, at 1.58 inches uncompressed, is small enough to easily fit within the base of the alarm clock. The spring is attached to a 1 inch by 1 inch piece of starboard in

order to focus the spring’s energy on a single point. When the alarm is set off, the solenoid is pulled in allowing the stopper to get the full force of the spring. When the spring system is being reset, the user pushes the speaker against the spring. When the spring is as fully compressed as it can get, the solenoid catches and the spring is locked in its compressed state.

The final design of the system can be seen in **Figure 11.2.7** below. The schematic shows how all of the parts are connected and interfaced.

# 7. Prototype Plan

## 7.1 Build and Implementation Strategy

The following was the original guideline that was used to construct the building and implementation strategy. After the completion of the research and design phases of the Senior Design project, the group will move onto to ordering/purchasing and receiving the parts. For more information on that part of the process, read the “Test Plan” section. The parts will start to be assembled, starting with the microcontroller. The group would like to test the microcontroller, make sure they have a good understanding of how it works, and to get a feel for how to do things with it (such as connect other pieces). The clock firmware would then be loaded onto the microcontroller. At the same time the firmware testing is being done, the display will be set up as well, so that the tests done for the clock will be visible to the design group. At the same time as those are being done, the group will also start to work on the physical implementation of the launcher. The launcher will be built as a separate entity first, to work out any kinks, before being modified and attached to the microcontroller. This is given a large portion of time, as the launcher is a complicated mechanism, and far more “mechanical” than anything the group has built before.

Next up will be the speakers. There isn’t a lot to “building them” but they will be set-up and prepared for connection via the launcher system. Next the power will be implemented. Setting up the power is a complex process, so it will given a longer portion of time than some of the other building sections. When the power system is being built, the Radio, USB, SD, and MP3 components will be implemented. The MP3 decoder will be attached to the microcontroller, as will the FM receiver. They can all be built at the same time because the USB, SD, and MP3 are all the same part, and the FM receiver goes along with them. Once those are done, the next part will be implementing the buttons and dials. Using the buttons, the firmware can be checked again, to make sure selections can be made.

As the buttons are being connected, the speaker and base connect system will be implemented and tested as well. Since the MP3 section and the speaker sections have been finished at this point, the connection between the base of the

alarm clock and the speakers can be tested with actual music, and that way if any errors arise, the section can be fixed as necessary. The battery charger system will also be built at this point. As one team member is testing out the sound output, the other can be working on getting the battery charger set up and finding the best implementation for it. As the charger building is coming to a close, the battery indicator will be built and can be examined by using the base to speaker connect until the batteries are drained (which is possible because of the order the things were built).

The next portion of the exploding alarm clock to be worked on is the internet connection for the microcontroller. Geoff Huston, the subcontractor for the web application, will come in after this and take the next one or two weeks to work on developing the web application, working in concert with the team as the internet connection section is finalized. The volume control for the speakers will also be built at this point, as will be the housing construction. The team will take their designs of the housing to Paul Anderson, who will use the equipment in the Machine Lab to build the housing to the design team's specifications. The design will be mounted into the housing, and the alarm clock will be tested extensively in its new form.

## 7.2 Test Plan

The following was the original guideline that was used to construct the test plan. When it comes to the design of the exploding alarm clock, so of the devices can be easily tested on their own, others need to be tested within a system of other parts. The designers tried their best to create a test plan that takes each parts' needs into account. The clock, display and microcontroller will all be tested in one session. The microcontroller can be tested on its own, but for time and for simplicities sake, it was thought that combining as many tests into one as possible would be the best plan. After the microcontroller is programmed with the clock firmware, and the display is set up, the display can be checked. If the display shows the current time at the correct size, and the time continues to update at the correct rate, and continues to show the correct time for one hour, then those parts will pass this part of the testing. One hour was chosen as the limit just to show that the seconds, minutes, and hours are all counted and shown correctly.

To test the launcher system, first it will be tested outside the alarm clock system, just to make sure the mechanics of it are appropriate. The motor will be sent a signal, and if the gears turn properly and the metal "deadbolt" is raised, the spring should expand and "push out" to its full form. After that it will be hooked up into the main system and the test will be to get the alarm clock to send the signal to the launching system only when the alarm has gone off. After that, the speaker, power, USB, Radio, SD and MP3 sections of the exploding alarm clock should be tested. To test the USB, SD, Radio and MP3 and the speaker sections,

the team can set up a SD card with some MP3 files and on, and set up a flash drive with some MP3 files and test to make sure there is the proper sound output from it. The radio is tested by the same manner, the radio can be turned on, and if the sound can be heard then the radio section passes. The test for the power system is to see if it can handle the power for the setup of the microcontroller with the MP3 decoder on it. The alarm clock can be left running for a period of time, with the alarm being set for a certain time between that. If it all seems to be working (and nothing gets too warm, or anything bad like that), the parts will pass the test.

Next the button and dials will be attached to the microcontroller and they will be tested by having one of the members attempt to change some settings with them. If the buttons do the changes they are supposed to, and the changes seem to hold (as in, the change isn't temporary), then the button section will be moved to the pass category. Next up is the speaker and base connection testing. This one is very simple. The speakers will be moved to a distant position and the MP3 or radio devices will be turned on and the sound will be checked for at both the speakers. It will also be tested at the switch between outputs (such as radio to SD) to make sure there are no errors in the sound output when switching, like some sort of noise pollution. The battery charger and battery indictor will be tested next. If the battery is left on in the speaker, in an attempt to run it down, the indictor light should eventually run down. If the light doesn't come on within a respectable amount of time, the batteries can be removed and their voltage tested with a multi-meter to see if it's below/above the threshold of the battery indictor. If it is below, the battery indicator circuit will be rechecked, with careful attention paid to the resistors that determine the point at which the light goes off. The batteries will be reattached, and if the light goes off (as it should at this point), then the indictor will pass the test.

The battery charger will be tested next, after the indicator is tested. Once the battery is drained (as tested by the indictor), the speaker system will be hooked back up to the main base of the alarm clock, and the charger system will be tested. The speakers will be left connected to the system for two hours. After that the batteries will be tested with a multi-meter. If their voltage has not increased since the point they were plugged in, the battery charger system is not working. The battery charger system will be checked against the design specifications to make sure that everything built as it should have been. If it appears to be correct, the connections will be re-checked, and the batteries will attempt to be charged again. If it works, the test has been passed by the battery charger.

Next up on the testing schedule is the internet connection for the base and the web application. They will be tested in unison, because their behavior is interconnected. The alarm clock will be connected to the router via the Ethernet connection. The design team will login to the web application and attempt to set the new alarm time. It will be tested with the alarm clock already being set, and then again with no alarm time set. If the alarm time is updated to the proper time,

then the internet connection will be considered a success. The web application will be tested on its own, for the web only sections of it. The login and sign-up section will be tested to make sure the website keeps a record of who has signed up already.

The final two sections to test are the housing of the speakers and the alarm clock, and the volume control on the speakers. The speaker controlled volume is of minimal importance, so if it does not work, it may stay that way. The speakers will be set to play music, and it will be checked to see if the dials on the speakers do actually change the volume of the output. The housing will be tested by latching it closed, and launching the speakers by setting off the alarm. The rest of the system will also be tested at this point, to make sure there are no errors that come up from the implementation of the entire system. The alarm will be set online (and then again manually), the different methods of alarm will be checked, and the speakers will be launched. If all goes according to plan, the system should be in perfect working condition.

# 8. Other

## 8.1. Related Projects:

While researching this project the designers stumbled upon a few other projects, some done by other senior design groups, others done for design competitions and some just done for fun. One of them is an alarm clock using a PIC microcontroller. Another is a PIC based alarm clock with internet capabilities, and the third is an alarm clock with some battery based components. None of them were exactly what the exploding alarm clock is, but some of them have a lot of similar parts and were helpful in coming up with the design of the exploding alarm clock.

Thomas, of the website thouters.be, posted an alarm clock that he built using the PIC brand of microcontrollers as the brains of it. He used the PIC's timer 0 interrupt (an interrupt service routine that gets called when timer 0 overflows) to keep track of time. Thomas' alarm clock has a menu system that the user can go through to set the clock time, set the alarm time, or start a countdown. It uses 4 push buttons for the control of the alarm clock. The display also has the ability to portray the time (and other characters) in multiple sizes: where the time takes up the whole screen or where the time is just a small portion of the screen. It connects to the user's PC via a serial port to get the initial time (if the user doesn't want to set it themselves). Like the exploding alarm clock project, this once uses a PIC microcontroller. Other than that, and the fact that it is an alarm clock, there aren't many other similarities.

D.J. Delorie, of the website delorie.com, entered his project in a competition sponsored by Microchip. He built an alarm clock that connects to the internet to

get the time as soon as it is powered on, it can be set by remote access and it can stream MP3s for the alarm sound. It uses the ENC28J60 for the Ethernet connection and an MP3 decoder chip for decoding the MP3s. Like the exploding alarm, D.J.'s alarm clock connects to the internet to determine the proper time. It uses the ENC28J60 chip to do so, like the exploding alarm clock. And like the exploding alarm clock design, it can be set remotely. This project is very similar to the base of the exploding alarm clock design, and was very helpful as some details had already been working out by D.J. Delorie that the design team was wondering how to do (like what Ethernet controller works well with the PIC microcontrollers).

The final related project was a battery powered alarm clock designed by Reynolds electronics. Reynolds electronics used a Serial Timekeeping Chip (the DS1307) as the brains of the clock portion, and the ATMEL AT90C2051 as the microcontroller. Their alarm clock also uses four pushbutton switches to set the clock and the alarm time. Like the exploding clock, it uses batteries for certain functions and it has pushbuttons allowing the user to set the time and to set the alarm. Unlike the other two, it does not compare as easily to the exploding alarm clock. Some useful code from this is that the buzzer can be set to turn off whenever the designers want (as opposed to a set time).

## 8.2. Facilities and Equipment:

There are mainly two facilities that were used for the designing and building of the exploding alarm clock. The first one is the Carpenter Shop of the Imperial Point Medical Center. With the help of James Baughman, the head of the Carpenter Shop almost anything could be constructed from base material using the equipment in the shop. For example, the housing for the alarm clock was built in this lab, provided that we brought the materials in. Anything of a more physical nature could have also been built in the Carpenter Shop, provided the designs were detailed enough. The other location is the Senior Design Lab, provided to UCF senior design students by UCF. It provided the design group with the electronic instrumentation that was needed to test the alarm clock as its being built. It has things like function generators, multi-meters, breadboards and oscilloscopes. It also has various resistors and other miscellaneous parts, so on the off chance that some resistor (to use resistors as an example) didn't seem to be working, it could be replaced to see if the resistor is bad, or it could have been changed out to see if another valued product might work better.

## 8.3. Consultants/Subcontractors:

It was decided early on that subcontractors and consultants would be used as little as possible. The difficulty of attempting to explain what the project is all about in enough detail that they wouldn't need constant supervision and doing so in enough time that the designers would still have time to build the rest of the

alarm clock is what wasn't liked. That, and the budgetary resources needed to hire a subcontractor are something this group doesn't have a lot of. That being said, there were two subcontractors/consultants that were found to be acceptable to the creation of the Exploding Alarm Clock: Geoff Huston as a consultant for the launching system, Charles Lord as a consultant for the launching system, James Baughman as a subcontractor for the Housing section of the project and QMS as a subcontractor for the dead bugging of the chips.

Geoff Huston is an upperclassman undergraduate college student at the University of Central Florida majoring in Computer Science. He has experience with many programming projects, and has personally built many electronic projects. That is why Geoff was approached for consultation Launching System part of the Alarm Clock creation. Geoff is a friend of the design team, and therefore a rapport has already been established between him and the group. Charles Lord is an engineer at Siemens and works with the design of systems all day long. Through some mutual acquaintances of the design team, Mr. Lord was exposed to the project and gladly offered his assistance. James Baughman is a carpenter at Imperial Point Medical Center. As such, he has experience with the more mechanical side of things, something the designers of this project are lacking. Since he is the father of one of the designers, he was willing to offer whatever services we needed. QMS, Quality Manufacturing Services, was a company that regularly assisted Senior Design groups with getting their chips on boards. The designers of the Exploding Alarm Clock used their services when necessary. All the consultants and subcontractors worked for affordable (if not free) rates. They know that Senior Design is a tough time for the designers and that the SD groups cannot afford big expenses. Mr. Huston, Mr. Lord and Mr. Baughman all offered their services for free, and QMS charged only for the parts required.

# 9. Administrative Documentation

## 9.1 Budget and Financing

Up to this point in time we have spent $489.56. This is a little more then our originally budget do to high shipping cost and a few incorrect purchase. The table bellows what has currently been spent and what it has been spent on.

| Final Budget | | | | | | |
|---|---|---|---|---|---|---|
| **Function** | **Part** | **Manufacturer** | **Vender** | **Price** | **Quanity** | **Cost** |
| **Ad4 decoder** | 14-D | Somo | SparkFun Electronics | $50.00 | 1 | $50.00 |
| **Bluetooth** | WT32 Bluetooth® Audio Module | Bluegiga | Semiconductorstore.com | $44.00 | 3 | $132.00 |
| **Crystal Oscillator** | CFS206 | Citizen | All Spectrum Electronics | $4.00 | 1 | $4.00 |
| **Demo Board** | Explorer 16 | Microchip | Microchip | $141.90 | 1 | $141.90 |
| **Display** | Serial LCD | Sparkfun Electronics | SparkFun Electronics | $25.00 | 1 | $25.00 |
| **Football** | Nerf | Nerf | Target | $5.00 | 1 | $5.00 |
| **Launcher** | Spring | McMasterCarr | McMasterCarr | $16.00 | 1 | $16.00 |
| **Launcher** | Solenoid | Guardian Electric | Skycraft | $2.98 | 1 | $2.98 |
| **Microcontroller** | PIC24FJ256GA106 | Microchip | Microchip | $6.14 | 3 | $18.42 |
| **Miscellaneous** | Shipping, etc. | Various | Various | $225.91 | 1 | $225.91 |
| **MP3 Decoder** | BU9438KV | Rohm Semiconductor | Digi-Key | $30.50 | 1 | $30.50 |
| **Power Supply** | Various Parts | Various | Various | $71.43 | 1 | $71.43 |
| **Programmer** | Pickit3 | Microchip | Microchip | $34.58 | 1 | $34.58 |
| **Push Button** | COM-00097,COM-08996 | SparkFun Electronics | SparkFun Electronics | $0.77 | 11 | $8.45 |
| **Push Button PCB** | COM-08963 | SparkFun Electronics | SparkFun Electronics | $1.95 | 1 | $1.95 |
| **SD Socket** | PRT-00136 | SparkFun Electronics | SparkFun Electronics | $3.95 | 1 | $3.95 |
| **Speakers** | iHome iHM79 | Apple Inc. | Apple Inc | $49.95 | 1 | $49.95 |
| **USB Cables** | PC USB AA Cable | | Allelectronics.com | $4.95 | 2 | $9.90 |
| **USB Connector** | HWS10492 | Phoenix Enterprises | Phoenix Enterprises | $0.57 | 1 | $0.57 |
| | | | | | **Total** | **$832.49** |

**Table 9.1.1**

## 9.2. Project Schedule and Milestone

The follow milestones were set up in such a manner as to ensure that everything was done in a proper time. The sections were also set up so that what was felt to be more important was accomplished first. On top of making the designers feel like they would be getting work done, the early sections are important to the overall design of the project and getting them done means the project works. For instance, a working clock is more important than proper housing. If the clock doesn't work, the project doesn't work. If the housing isn't proper, the clock still works. Finally, the last reason for the structure of the milestone is so that all of the designers' different strengths could be utilized at the same time. There will be no moments where one of the designers has nothing to do.

| Fall Semester | | | | | | | |
|---|---|---|---|---|---|---|---|
| | September 1/2 | September 2/2 | October 1/2 | October 2/2 | November 1/2 | November 2/2 | December 1/2 |
| Initial Design Doc | | | | | | | |
| General Research | | | | | | | |
| Final Design Doc | | | | | | | |
| Clock | | | | | | | |
| Launcher | | | | | | | |
| Wireless Reciever | | | | | | | |
| Net Connect for Base | | | | | | | |
| Speaker+Base Connect | | | | | | | |
| USB | | | | | | | |
| Microcontroller | | | | | | | |
| Radio/MP3 | | | | | | | |
| Buttons/Dials | | | | | | | |
| Speaker | | | | | | | |
| Volume Control | | | | | | | |
| Battery Holder + Charger | | | | | | | |
| Battery Indicator | | | | | | | |
| Power | | | | | | | |
| Display | | | | | | | |
| Speaker Housing | | | | | | | |
| Base Housing | | | | | | | |
| Website (for clock setting) Design | | | | | | | |
| Formatting/Fixing/Combining | | | | | | | |

**Table 9.2.1**

| Spring Semester | | | | | | | |
|---|---|---|---|---|---|---|---|
| | January 2/2 | February 1/2 | February 2/2 | March 1/2 | March 2/2 | April 1/2 | April 2/2 |
| | | | | | | | |
| Project Documentation | | | | | | | |
| Microcontroller | | | | | | | |
| Clock | | | | | | | |
| Display | | | | | | | |
| Launcher | | | | | | | |
| Speaker | | | | | | | |
| Power | | | | | | | |
| Radio | | | | | | | |
| USB/SD/MP3 | | | | | | | |
| Buttons/Dials | | | | | | | |
| Speaker+Base Connect | | | | | | | |
| Battery Charger | | | | | | | |
| Battery Indicator | | | | | | | |
| Net Connect for Base | | | | | | | |
| Website (for clock setting) | | | | | | | |
| Housing | | | | | | | |
| Volume Control | | | | | | | |
| Final Demonstration | | | | | | | |
| Critical Design Review presentation | | | | | | | |
| Combining the paper | | | | | | | |
| Final Tests | | | | | | | |

**Table 9.2.2**

## 10. Project Summary and Conclusion

The research and design stage of the project proved to be a more difficult task that anticipated but the final design described in this paper should prove to be exactly what is needed to construct the alarm clock. The designers have developed an alarm clock that has projectile speakers that are launched when the alarm is triggered. The speakers will play the user selected alarm sound wirelessly until they are returned to the base. The user options for alarm sounds include user selected music files. All of the interfacing commands are available to the user through buttons on the housing.

There are a few issues that the designers ran in to when it came time to the building of the Exploding Alarm Clock. One of the concerns of the designers was that it was difficult to properly distribute power from the power supply to each individual component. The complexity of this task seemed to be beyond the scope of the designers' knowledge, however, when it came time to build the circuit the testing helped in figuring out how to do this. Another concern that the designers had was the launcher mechanism. It was unclear how the solenoid system was going to perform, but this was confronted and figured out when the actual system was built and tested. The spring was also cause for concern, as it was also unclear whether it would function as expected. All of these things were tested when the system was built, and correct solutions were implemented to create the working prototype. The last concern dealt with the actual connection of the parts for the designing of the circuit. The complexity of combining all of the parts and having them interface correctly did cause the designers some grief, but through research and testing the design was completed.

Through the research and design for this project the designers established a foundation for the final building of the Exploding Alarm Clock. The research gave the designers a set path to take for the design of the system. It also provided a number of different secondary plans to follow incase anything from the initial strategy failed. Through the testing and building phases a final design and working prototype was completed.

# 11. Appendices

## 11.1 Bibliography


1. Johnson, Joel. “How the "Apple Tax" Boosts Prices on iPod & iPhone Accessories”. Popular Mechanics. July 10, 2008.

2. "How does a vibrating cell phone or pager work?." 28 April 2000. HowStuffWorks.com. <http://www.howstuffworks.com/question368.htm> 21 October 2009.

3. Wexler, Sarah Z. “THE PHONE THAT TOUCHES YOU BACK.” Popular Science April 2007: 52-53. <http://books.google.com/books?id=apqd0YXTtkMC&pg=PA52&dq=vibration+works+phone+tech#v=onepage&q=&f=false>

4. Harris, Tom. "How Water Blasters Work." 05 July 2001. HowStuffWorks.com. <http://entertainment.howstuffworks.com/water-blaster.htm> 22 October 2009

5. Paintball Equipment. <http://en.wikipedia.org/wiki/Paintball_equipment> Oct 23 2009

6. Harris, Tom. "How Paintball Works." 22 May 2001. HowStuffWorks.com. <http://entertainment.howstuffworks.com/paintball.htm> 23 October 2009.

7. Clark, Josh. "Is your vinyl siding killing you?." 16 November 2007. HowStuffWorks.com. <http://home.howstuffworks.com/home-improvement/repair/vinyl-siding-lethal.htm> 26 October 2009.

8. Steel SAE1010 <http://www.amazon.com/Steel-SAE1010-Rolled-Number-Finish/dp/B000FPD6CO/ref=sr_1_3?ie=UTF8&s=industrial&qid=1256614072&sr=1-3> Oct 27 2009

9. Glass Cages < http://www.glasscages.com/?sAction=ViewCat&lCatID=42> Oct 27 2009

10. Professional Plastics < http://www.professionalplastics.com/PLEXIGLASS-ACRYLICSHEET-EXTRUDED> Oct 28 2009

11. Plexiglas Primer < http://www.eplastics.com/Plastic/Plastics_Library/Plexiglass-Primer-and-History-of-Plexiglas-Acrylic;jsessionid=0a0101441f4313f0a751e8c249c187d1a207fbf16a25.e3eSc3uNaNuTe34Pa38Ta38Qaxz0> Oct 28 2009

12. Regal Plastics <http://www.regal-plastics.com/lexan.html> Oct 29 2009

13. Vending machines <http://www.enotes.com/how-products-encyclopedia/vending-machine> Oct 29 2009

14. Lexan <http://www.amazon.com/Clear-Polycarbonate-Sheet-250-Thick/dp/B000FPC3Z0/ref=sr_1_2?ie=UTF8&s=industrial&qid=1256864078&sr=8-2> Oct 29 2009

15. Lexan Consumer Benefits <http://www.sabic-ip.com/gep/Plastics/en/ProductsAndServices/ConsumerBenefits/lexan.html> Oct 29 2009

16. Pro Glass Windows <http://proglasswindows.com/> Oct 29 2009

17. Valdes, Robert. "How Xbox 360 Works." 29 November 2006. HowStuffWorks.com. <http://electronics.howstuffworks.com/xbox-three-sixty.htm> 30 October 2009.

18. Low Battery Indicator <http://www.maxim-ic.com/appnotes.cfm/an_pk/1872> Oct 30 2009

19. Whats the best battery? <http://www.batteryuniversity.com/partone-3.htm> Nov 3 2009

20. The nickel-based battery, its dominance and the future < http://www.batteryuniversity.com/partone-4.htm> Nov 3 2009

21. Can the lead-acid battery compete in modern times? < http://www.batteryuniversity.com/partone-6.htm> Nov 3 2009

22. Is Lithium-ion the ideal battery? < http://www.batteryuniversity.com/partone-5.htm> Nov 4 2009

23. Will the reusable alkaline battery have a future? < http://www.batteryuniversity.com/partone-7.htm> Nov 6 2009

24. Belkin Wireless G Router <http://www.amazon.com/Belkin-Wireless-G-Router-Cable-Gateway/dp/B00008ZPJU/ref=sr_1_32?ie=UTF8&s=electronics&qid=1257725980&sr=1-32> Nov 8 2009

25. SMC EZ Connect <http://www.amazon.com/SMC-SMCWPCI-G-Connect-2-4GHz-Wireless/dp/B000A0K4M4/ref=sr_1_14?ie=UTF8&s=electronics&qid=1257727578&sr=1-14> Nov 8 2009

26. WiPort <http://www.lantronix.com/device-networking/embedded-device-servers/wiport.html> Nov 8 2009

27. Brain, Marshall, and Tracy V. Wilson. "How WiFi Works." 30 April 2001. HowStuffWorks.com. <http://computer.howstuffworks.com/wireless-network.htm> 08 November 2009.

28. Franklin, Curt, and Julia Layton. "How Bluetooth Works." 28 June 2000. HowStuffWorks.com. <http://electronics.howstuffworks.com/bluetooth.htm> 08 November 2009.

29. Experience Wacky Applications <http://www.bluetooth.com/Bluetooth/Experience/On_The_Cutting_Edge.htm> Nov 11 2009

30. Wacky Applications <http://www.bluetooth.com/Bluetooth/Experience/On_The_Cutting_Edge.htm> 11 Nov 2009

31. Charging Nickel-based batteries <http://www.batteryuniversity.com/partone-11.htm> 12 Nov 2009

32. Pic Alarm Clock< http://www.thouters.be/PicAlarmClock> 12 01 09

33. Microchip 16 bit Embedded Control Design Contest < http://www.circuitcellar.com/microchip2007/winners/second.html > 12 01 09

34. AT89C2051 Clock <http://www.rentron.com/at89c205.htm > 12 01 09

35. http://pinouts.ru/

36. Atmel.com

37. http://www.vishay.com/

38. http://www.rohmelectronics.com/

39. SparkFun.com

40. Microchip.com

41. Ti.com

42. “CFA635-TFE-KU1.” Crystalfontz Liquid Crystal Display. 2009. 11-19-09. <http://www.crystalfontz.com/products/character_lcd_displays.html>

43. SC2004—20x4 Characters Serial LCD Module. 2009. 11-20-09. <http://www.siliconcraft.net/pdf/SC2004%2020x4%20Characters%20Serial%20LCD%20Module.pdf>

44. “BXR1220.” Altec Lansing. 2009. 12-1-09. <http://www.alteclansing.com/index.php?file=north_product_detail&iproduct_id=bxr1220>

45. “WT32 Bluetooth Audio Module.” BlueGiga. 2009. 12-1-09. <http://www.bluegiga.com/WT32_Bluetooth_Audio_Module>

46. “nRF24Z1 Transceiver for Audio Streaming” Nordic Semiconductor. 2009. 12-8-09. <http://www.nordicsemi.com/index.cfm?obj=product&act=display&pro=86#>

# 11.2 Figures

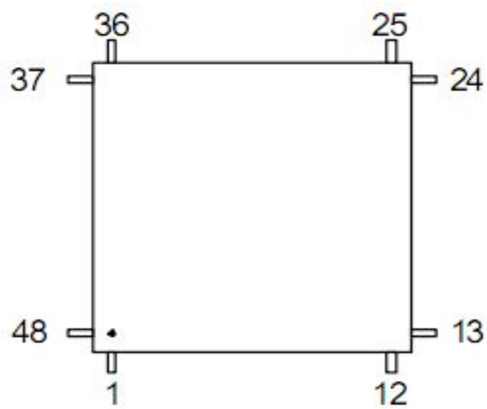
# Figure 11.2.1

| Pin | Signal | Description |
|---|---|---|
| 1 | GND | Ground (-), internally connected with Pin 2 on iPod motherboard |
| 2 | GND | Audio & Video ground (-), internally connected with Pin 2 on iPod motherboard |
| 3 | Right | Line Out - R (+) (Audio output, right channel) |
| 4 | Left | Line Out - L(+) (Audio output, left channel) |
| 5 | Right In | Line In - R (+) |
| 6 | Left In | Line In - L (+) |
| 8 | Video Out | Composite video output (only when slideshow active on iPod Photo) |
| 9 | S-Video Chrominance output | for iPod Color, Photo only |
| 10 | S-Video Luminance output | for iPod Color, Photo only |
| 11 | GND | Serial GND |
| 12 | Tx | ipod sending line, Serial TxD |
| 13 | Rx | ipod receiving line, Serial RxD |
| 14 | RSVD | Reserved |
| 15 | GND | Ground (-), internally connected with pin 16 on iPod motherboard |
| 16 | GND | USB GND (-), internally connected with pin 15 on iPod motherboard |
| 17 | RSVD | Reserved |
| 18 | 3.3V | 3.3V Power (+)<br>Stepped up to provide +5 VDC to USB on iPod Camera Connector. If iPod is put to sleep while Camera Connector is present, +5 VDC at this pin slowly drains back to 0 VDC. |
| 19,20 | +12V | Firewire Power 12 VDC (+) |
| 21 | Accessory Indicator/Serial enable | Different resistances indicate accessory type:<br>1kOhm - iPod docking station, beeps when connected<br>10kOhm - Takes some iPods into photo import mode<br>68kOhm - makes iPhone 3g send audio through line-out without any messages<br>500kOhm - related to serial communication / used to enable serial communications Used in Dension Ice Link Plus car interface<br>1MOhm - Belkin auto adaptor, iPod shuts down automatically when power disconnected Connecting pin 21 to ground with a 1MOhm resistor does stop the ipod when power (i.e. Firewire-12V) is cut. Looks to be that when this pin is grounded it closes a switch so that on loss of power the Ipod shuts off. Dock has the same Resister. |
| 22 | TPA (-) | FireWire Data TPA (-) |
| 23 | 5 VDC (+) | USB Power 5 VDC (+) |
| 24 | TPA (+) | FireWire Data TPA (+) |
| 25 | Data (-) | USB Data (-) |
| 26 | TPB (-) | FireWire Data TPB (-) |
| 27 | Data (+) | USB Data (+)<br>Pins 25 and 27 may be used in different manner. To force the iPod 5G to charge in any case, when USB Power 5 VDC (pin 23) is fed, 25 must be connected to 5V through a 10kOhm resistor, and 27 must be connected to the Ground (for example: pin 1) with a 10kOhm resistor.<br><br>iPod 5G can also be forced to charge by attaching the data + and the data - pins to the 5v via a 10k Ohm resistor ( BOTH PINS) and connecting pin 16 to the 5v (ground). (Confirmed working with iPod 5G 20GB)<br><br>To charge an iPhone 3G / iPod Touch 2nd gen, usb data- (25) should be at 2.8v, usb data+(27) should be at 2.0v. This can be done with a few simple resistors: 33k to +5v (23) and 22k to gnd(16) to obtain 2v and 33k to +5v and 47k to gnd to obtain 2.8v. This is a notification to the iphone that it is connected to the external charger and may drain amps from the usb. |
| 28 | TPB (+) | FireWire Data TPB (+) |
| 29,30 | GND | FireWire Ground (-) |

## Figure 11.2.2

```
Back side of dock connector;
 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
 1 3 5 7 9 11 13 15 17 19 21 23 25 27 29
```

## Figure 11.2.3




## Figure 11.2.4

QFP48 Package Pinout

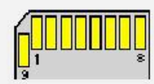
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | GND | 13 | GND | 25 | PA13 | 37 | GND |
| 2 | TCK | 14 | ADVREF | 26 | PA14 | 38 | DP |
| 3 | TDI | 15 | VDDANA | 27 | PA15 | 39 | DM |
| 4 | TDO | 16 | VDDOUT | 28 | PA16 | 40 | VBUS |
| 5 | TMS | 17 | VDDIN | 29 | PA17 | 41 | VDDPLL |
| 6 | VDDCORE | 18 | VDDCORE | 30 | PA18 | 42 | VDDCORE |
| 7 | PA03 | 19 | GND | 31 | PA19 | 43 | PA24 |
| 8 | PA04 | 20 | PA09 | 32 | PA20 | 44 | PA25 |
| 9 | PA05 | 21 | PA10 | 33 | PA21 | 45 | PA26 |
| 10 | PA06 | 22 | PA11 | 34 | PA22 | 46 | PA27 |
| 11 | PA07 | 23 | PA12 | 35 | PA23 | 47 | RESET_N |
| 12 | PA08 | 24 | VDDIO | 36 | VDDIO | 48 | VDDIO |

## Figure 11.2.5

| Pin | Name | Cable color | Description |
|---|---|---|---|
| 1 | VCC | Red | +5 VDC |
| 2 | D- | White | Data - |
| 3 | D+ | Green | Data + |
| 4 | GND | Black | Ground |


## Figure 11.2.6

| Pin | SD Mode | | | SPI Mode | | |
|---|---|---|---|---|---|---|
| | Name | Type | Description | Name | Type | Description |
| 1 | CD/DAT3 | I/O/PP | Card detection / Connector data line 3 | CS | I | Chip selection in low status |
| 2 | CMD | PP | Command/Response line | DI | I | Data input |
| 3 | Vss1 | S | Supply voltage (earth) | VSS | S | Supply voltage |
| 4 | Vdd | S | Power supply | VDD | S | Power supply |
| 5 | CLK | I | Clock | SCLK | I | Clock |
| 6 | Vss2 | S | Supply voltage | VSS2 | S | Supply voltage |
| 7 | DAT0 | I/O/PP | Connector data line 0 | DO | O/PP | Data output |
| 8 | DAT1 | I/O/PP | Connector data line 1 | RSV | | |
| 9 | DAT2 | I/O/PP | Connector data line 2 | RSV | | |



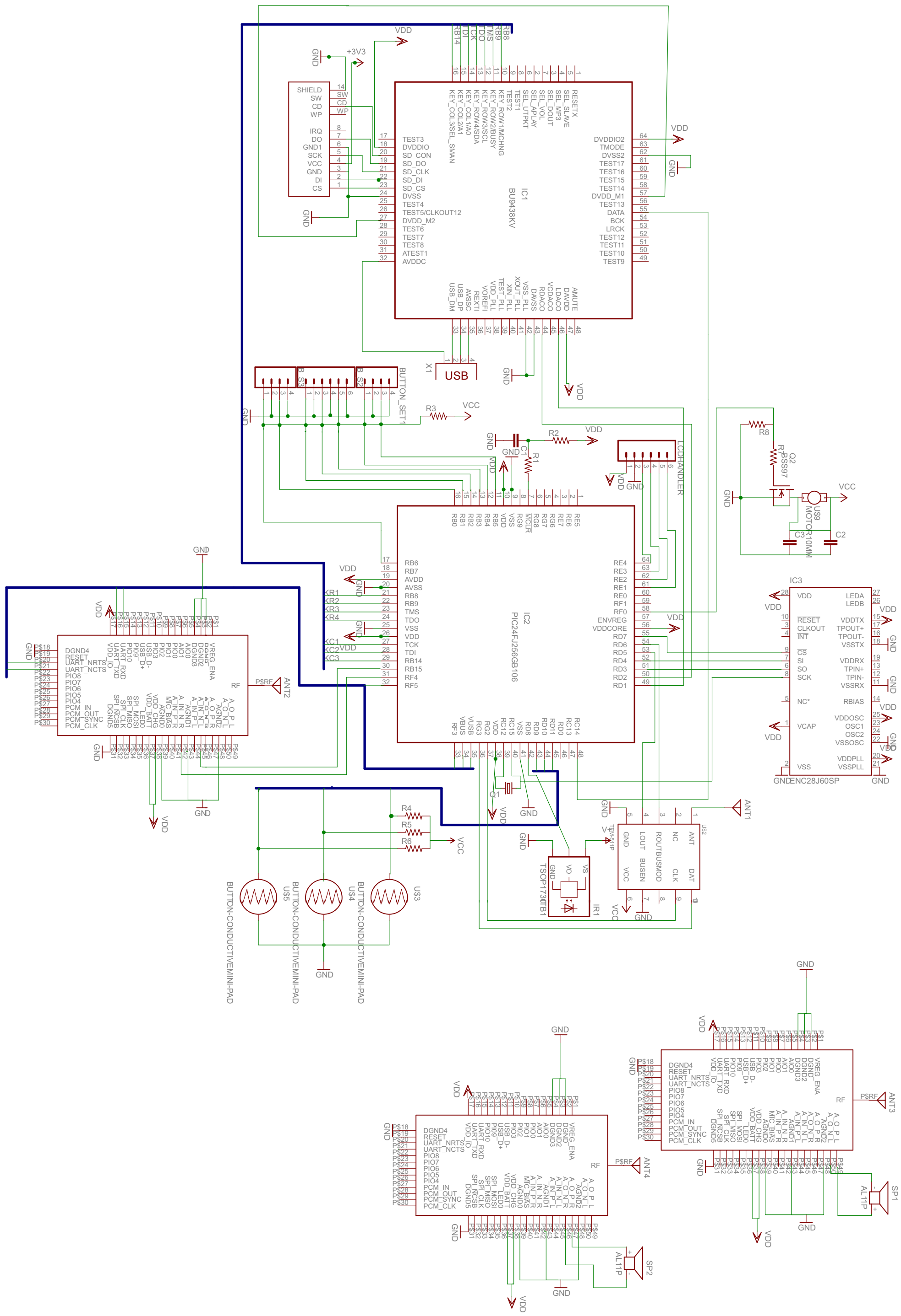



**Figure 11.2.7**

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Branden Maynes
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Computer and Electrical Engineering
University of Central Florida

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Good luck with the project,

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Cadex Electronics Inc.

>>> Branden Maynes <branden.maynes@knights.ucf.edu> 2009-10-31 4:53:34 pm >>>

Hello, my name is Branden Maynes. I'm a senior computer engineering student at the University of Central Florida in Orlando, Florida. My group and I are currently working on our senior design project and as part of it, we're doing some research on batteries. We were wondering if we could use the tables/figures/pictures on your batteryuniversity.com site in our report. We would of course cite whatever we use and we would not edit or change anything. Thank you in advance for your help.

-Branden Maynes

Atmel:

From De Caro, Michael <Michael.DeCaro@atmel.com>

David,

You may use the images with proper acknowledgement of ownership by Atmel.

Regards,

Michael

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Email between Branden Maynes and ProGlassWindows

HI Branden,

Hi Please feel free to use the image that you want . I would like it if you did a attachment to my web site so I could have it for our use. If you need any other pics let me know.

Bob

-----Original Message-----
From: Branden Maynes [mailto:branden.maynes@knights.ucf.edu]
Sent: Thursday, October 29, 2009 9:51 PM
To: info@proglasswindows.com
Subject: use of pictures

Hi, my name is Branden Maynes. I'm a senior computer engineering student at the University of Central Florida, and as part of my Senior Design project, I'm doing some research on Lexan. I was looking for examples of Lexan being used and I stumbled upon your site. I was wondering if I could use the bird's eye view photo of the Ford Racing Mustang on the "formed windows" page of your website as part of my report? I will, of course, cite your webpage as the source of your page. Thank you in advance for your assistance.

-Branden Maynes

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---

Yup, go for it. Good luck with your project.

Best,
Xavier

On Nov 30, 2009, at 7:04 PM, Nathan Johnson wrote:

> Yes I'm a senior at the University of Central Florida. We are designing a mp3 alarm clock and are looking at using the iHome iHM77 "Capsule Speakers" as speakers for our clock. So I was wondering if I could use the pictures you took of them. So I need the pictures to show size mainly.
>
> Thank You,
> Nathan Johnson
>
> On Nov 30, 2009, at 10:00 PM, Xavier Lanier wrote:
>
>> Hi Nathan,
>>
>> Thank you for being curteous and asking permission. I'm sure we can let you use them as long as it's for non-commercial use.
>>
>> Could you please tell me about your project, what photos you want to use and where they'll be seen?
>> Also, can you tell me what grade/year you're in and what school you're attending?
>>
>> Best,
>> Xavier
>>
>> On Nov 30, 2009, at 5:45 PM, Nathan Johnson wrote:
>>
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>>>
>>> I was wondering who I would need to talk to to get permission to use images from your site in a project for school. So if you could just get back to me or forward this on to who it needs to get to it would be much appreciated. Thank you for your time.
>>>
>>> Nathan Johnson

# Crystalfontz Permission

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**Subject:** **Re: Website**
**Date:** November 24, 2009 6:41:21 PM EST
**To:** Nathan Johnson <nate.johnson2010@gmail.com>

---

Thanks and good luck.  I will look over your project when you send me the link.
Jean

On Mon, Nov 23, 2009 at 2:28 PM, Nathan Johnson <nate.johnson2010@gmail.com> wrote:

> We have to put together a website for the final project. so i'll send you a link to that.
>
> On Nov 23, 2009, at 5:21 PM, Jean Agte wrote:
>
>> Hi Nathan,
>>
>> Yes, you have our permission to use the CFA635 photos and documents for your senior project.  If it's not too much trouble, it would be fun for us to see your final paper.  Would you mind emailing us a copy of your finished paper?
>>
>> Thanks and good luck!
>> Jean
>>
>> Jean Agte, COO
>> Crystalfontz America, Incorporated
>> 12412 East Saltese Avenue
>> Spokane Valley, WA 99216-0357
>> jean@crystalfontz.com http://www.crystalfontz.com
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>>>
>>> Nathan Johnson
>>>
>>> On Nov 23, 2009, at 1:28 PM, Jean Agte wrote:
>>>
>>>> Nathan Johnson:
>>>> Thank you for your interest in Crystalfontz.  I wish you the best on your senior project.
>>>>
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>>>>
>>>> Let me know if you have questions.
>>>>
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>>>> Crystalfontz America, Incorporated
>>>> 12412 East Saltese Avenue
>>>> Spokane Valley, WA 99216-0357
>>>> jean@crystalfontz.com http://www.crystalfontz.com
>>>> voice (509) 892-1200 fax (509) 892-1203 US toll-free (888) 206-9720
>>>> --- Please consider the environment before printing this e-mail. Thank you. ---
>>>>
>>>>> From: **Nathan Johnson** <nate.johnson2010@gmail.com>
>>>>> Date: Mon, Nov 23, 2009 at 5:28 AM
>>>>> Subject: Website
>>>>> To: sales@crystalfontz.com
>>>>>
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>>>>> Thank you for your time.
>>>>> Nathan Johnson

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**Date:** November 11, 2009 1:43:30 PM EST
**To:** <nate.johnson2010@gmail.com>

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www.allelectronics.com
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Sent: Tuesday, November 10, 2009 12:28 PM
To: Mail User
Subject: Website

I was emailing to find out if I could have permission to use images and spec sheets from your website for my senior design project at the University of Central Florida.

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# Pinouts.ru Permission



PINOUTS.RU

## Handbook of hardware pinouts, cables schemes and connectors layouts

**Computer Pinouts**



**Connectors of Devices**



**Cables & Adapters Schemes**





*We are collecting information about hardware interfaces of modern and obsolete devices, including pinouts of ports, expansion slots, and other connectors of computers and different digital devices. This information is essential for everyone who wants to investigate insights of modern computer hardware, explore ways it's works, design devices with computer connection.*

Our handbook includes more than **1000** documents :

- Pinouts of computer hardware components, internal connectors, buses and input/output ports (i.e. PC Serial port pinout, PCI Bus ).
- Pinouts and brief information about some common computer hardware interfaces (such a RS232 interface, USB, ATA/IDE).
- Pinouts of audio/video connectors (i.e. S-Video connector or VGA connector pinout)
- Pinouts of cellular phones, consumer audio/video hardware and over devices (i.e. Nokia Pop port pinout)
- Schemes of computer peripherals and other devices cables and converters (i.e. USB to RS232 serial converter schematic)
- Layout and numbering scheme of common and device-specific connectors

All documents are free and available online in english and russian languages.

The hardware covered by our project includes modern (PC, Apple Macintosh,...) and obsolete (Atari, Commodore, MSX,...) computers, mobile phones and some other devices (like GPS units, PDA,...).
Most of documents have been created from public-available internet sources (with link(s) to origin(s) included). Feel free to contact webmaster if you believe that any of this publications affects your author's rights.

You are welcome to ask any questions about **pinouts, connectors and wiring** at the forum. Here is a list of some abbreviations used.

Content of this site is a result of collective work. **Something left uncovered? You may add new pinouts to this collection!** Submit your information to pinout helper and webpage will be created with help of YOUR knowledge.
Feel free to correct existing documents, add explanations, fix errors, suggesting related links at this forum (don't forget to include title of document(s) affected).
In addition, you may submit your suggestions and comments via guestbook.

Please, link to us if our information was useful for you!

I'm grateful to Joakim Ogren and Hardware Book team for Hardware Book project and a lot of information.

**Recent forum questions**

>>Huawei 3g Modem or any USB Modem
>>Need vodafone 850 crystal pinouts please!!!!
>>HDMI to DVI and RCA Audio
>>Internet source for mini-b with a 4-x pure short to standard usb - Suggestions?

**Are you able to help?**

**Search @ pinouts.ru**

Sample query: *rs-232*

titles only

**Show connectors of**

- everything
- cell phones
- devices
- standard interfaces

**Alternatives**

**Forum**

Show all pinouts

SUBMIT new pinout!

switch to russian

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